NASA-TM-X-74296

# Research and Technology Objectives and Plans

# SUMMARY

(NASA-TM-X-74296) RESEARCH AND TECHNOLOGY OBJECTIVES AND PLANS. A SUMMARY, FY 1977 RESEARCH AND TECHNOLOGY PROGRAM (National Aeronautics and Space Administration) 199 p HC $4.75 CSCL 05B G3/82

N77-12925

Unclas 56702

NASA
National Aeronautics and Space Administration

## FISCAL YEAR 1977 RESEARCH AND TECHNOLOGY PROGRAM

# INTRODUCTION

This publication represents the NASA Research and Technology program for FY 1977. It is a compilation of the "Summary" portions of each of the RTOPs (Research and Technology Objectives and Plans) used for management review and control of research currently in progress throughout NASA. The *RTOP Summary* is designed to facilitate communication and coordination among concerned technical personnel in government, in industry, and in universities. We believe also that this publication can help to expedite the technology transfer process.

The *RTOP Summary* is arranged in five sections. The first section contains citations and abstracts of the RTOPs. Following this section are four indexes: Subject, Technical Monitor, Responsible NASA Organization, and RTOP Number.

The Subject Index is an alphabetical listing of the main subject headings by which the RTOPs have been identified.

The Technical Monitor Index is an alphabetical listing of the names of individuals responsible for the RTOP.

The Responsible NASA Organization Index is an alphabetical listing of the NASA organizations which developed the RTOPs contained in the Journal.

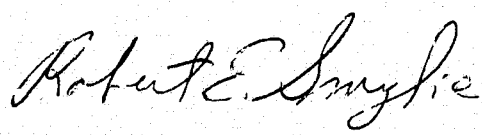
The RTOP Number Index provides a cross-index from the RTOP number assigned by the NASA responsible organization to the corresponding accession number assigned sequentially to the RTOPs in *RTOP Summary*.

As indicated above, responsible technical monitors are listed on the RTOP summaries. Although personal exchanges of a professional nature are encouraged, your consideration is requested in avoiding excessive contact which might be disruptive to on-going research and development.

Any comments or suggestions you may have to help us evaluate or improve the effectiveness of the *RTOP Summary* would be appreciated. These should be forwarded to:

National Aeronautics and Space Administration
Office of Aeronautics and Space Technology
Washington, D.C. 20546

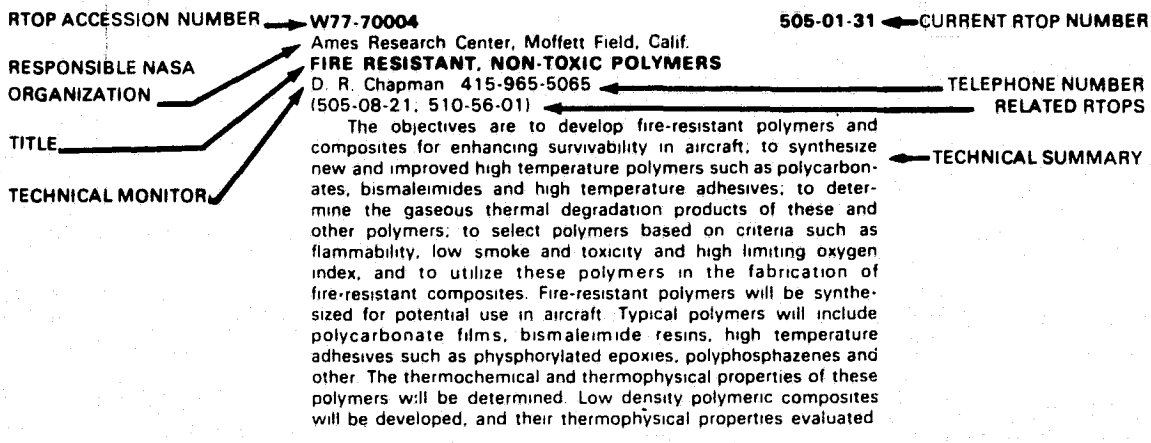
Attn: Edna F Templeton
Resources and Management Systems Division (RMP)



Robert E. Smylie
Acting Associate Administrator for
Aeronautics and Space Technology

# TABLE OF CONTENTS

# TYPICAL CITATION AND TECHNICAL SUMMARY



# RESEARCH AND TECHNOLOGY OBJECTIVES AND PLANS

*a summary* **FISCAL YEAR 1977**

## OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY

### Aeronautics Research and Technology Base

**W77-70001** **505-01-12**
Lewis Research Center, Cleveland, Ohio.
**ADVANCED PROPULSION MATERIALS**
H. B. Probst 216-433-4000
(510-53-01)

The objective of this RTOP is to provide improved materials, both metallic and nonmetallic, and processes for use in advanced air-breathing propulsion systems, particularly for aeronautical applications. Materials are sought that offer improvements not only in technical performance but also in economy in terms of costs and life. The classes of materials to be investigated include primarily directionally solidified eutectics, dispersion strengthened alloys, protective coatings, and ceramics. Improvements are sought by basic changes applied to existing and new materials. Basic research, both in-house and by university grants, relevant to the high temperature behavior of engine materials is also conducted. Results of this basic effort then supply guidance for the more applied and application oriented program. Material improvements are judged by measurements of mechanical and physical properties as well as qualitative evaluations of microstructural features and performance in simulated-engine environments. Ultimately, highly promising materials and processes that result from this program become candidates for the MATE program to accomplish scale-up and full scale engine testing. Emphasis is on advanced materials for aircraft gas turbine blades, vanes, disks, and seals.

**W77-70002** **505-01-21**
Ames Research Center, Moffett Field, Calif.
**FATIGUE, FRACTURE AND LIFE PREDICTION**
D. R. Chapman 415-965-5065

Research is underway to improve the technology required to insure reliability of both metallic and composite structures for the economic life of the aircraft. Emphasis is placed on determining the combined effect of mechanical loads and environmental factors on component integrity and durability. Specific programs to be carried out include: the prediction of time-dependent fracture of structural metals caused by subcritical crack growth; the stress corrosion cracking of metal alloys in simulated service environments; the study of the mechanisms of failure of fibrous composite materials; and the durability of epoxy-based composites in moist environments. Experiments will be conducted on metals under conditions of static and cyclic loading in a variety of environments to determine the mechanisms and kinetics involved in the process of environmental embrittlement. Experiments will also be conducted on fibrous composite materials to determine the relation of load conditions and the properties of matrix, fiber, and interface to failure behavior. Experimental and analytical programs will relate the moisture level and distribution in composites to internal stress state and resulting mechanical allowables. In all the above cases, experiments will be related through appropriate analyses to responsible failure mechanisms and, where possible, to anticipated service conditions.

**W77-70003** **505-01-21**
Lewis Research Center, Cleveland, Ohio.
**FATIGUE, FRACTURE, AND LIFE PREDICTION**
M. H. Hirschberg 216-433-4000

The major objective is to obtain a better understanding of the failure mechanisms that are involved in the application of conventional as well as composite materials to aeronautical propulsion systems so that presently available and advanced materials can be used more efficiently. A second major objective is to develop methods for predicting the life of specimens as well as propulsion system components when they are subjected to constant temperature and monotonic loads or to complex patterns of temperatures and cyclic loads as a function of time. To achieve these objectives, research is underway to extend existing life prediction techniques and analyses, to develop new methods for determining the stress and strain distribution in the vicinity of discontinuities such as flaws or cracks, as well as to understand the effect of these discontinuities on material behavior when subjected to various environmental conditions. In addition, microstructure as determined by composition and processing is being studied as an influence on the fracture properties of high strength alloys. Various approaches are also being examined for predicting the time to initiation of the first detectable cracks resulting from mechanical and thermal fatigue. Standard test methods are being developed to properly characterize the fatigue and fracture behavior of materials and to provide economical methods for alloy product quality control. (Scope change - initiate work with composites.)

**W77-70004** **505-01-31**
Ames Research Center, Moffett Field, Calif.
**FIRE RESISTANT, NON-TOXIC POLYMERS**
D. R. Chapman 415-965-5065
(505-08-21; 510-56-01)

The objectives are to develop fire-resistant polymers and composites for enhancing survivability in aircraft; to synthesize new and improved high temperature polymers such as polycarbonates, bismaleimides and high temperature adhesives; to determine the gaseous thermal degradation products of these and other polymers; to select polymers based on criteria such as flammability, low smoke and toxicity and high limiting oxygen index, and to utilize these polymers in the fabrication of fire-resistant composites. Fire-resistant polymers will be synthesized for potential use in aircraft. Typical polymers will include polycarbonate films, bismaleimide resins, high temperature adhesives such as phosphorylated epoxies, polyphosphazenes and other. The thermochemical and thermophysical properties of these polymers will be determined. Low density polymeric composites will be developed, and their thermophysical properties evaluated.

The pyrolysis and combustion products of polymers and composites will be determined. Polymers with optimum thermophysical properties, low flammability and low smoke evolution will be selected.

**W77-70005** **505-01-32**
Ames Research Center, Moffett Field, Calif.
**FIRE-RETARDANT AND LASER COUNTERMEASURE MATERIALS FOR MILITARY PROGRAMS**
D. R. Chapman 415-965-5065
(505-01-31)

The objectives are to apply state-of-the-art and advanced fire-retardant and laser resistant materials and technology to support current and future DOD survivability programs, to study the reaction parameters governing the thermal decomposition of polymers at high heating rates as related to lasers, to study the processing parameters of the NASA developed transparencies necessary to provide an aircraft canopy which is fire, laser and impact resistant, and to study effects of solid fire extinguishants on-board engine nacelle fires and to develop thermal protection concepts and materials for lightweight ships and small diameter missiles. Assistance will be provided the military to reduce the vulnerability of flight and missile systems when subjected to an induced fire environment and to provide laser hardened materials for selected applications. Full-scale testing of canopies using the NASA developed materials will be conducted and compared to baseline materials. Initial design and analysis of a thermal protection system for lightweight ships will be performed. The processing parameters of the NASA M-30 coating for small diameter missiles will be investigated in pilot operation. The evaluation and study of the solid fire extinguishants will be conducted in the fire-hot surface simulator for pre full-scale evaluation.

**W77-70006** **505-01-33**
National Aeronautics and Space Administration, Washington, D.C.
**ADVANCED MATERIALS FOR AERONAUTICS**
Joseph Maltz 202-755-2395

Advisory services to guide R and D in advanced aerospace materials and structures are provided by the National Materials Advisory Board, a unit of the Division of Engineering, National Research Council, National Academy of Sciences and National Academy of Engineering. Ad Hoc Panel Studies of specialized areas of technology are made as the need arises. Support of these studies is frequently shared with DOD. One or two-day workshop reviews of areas of technology whose status or level of complexity does not require a formal Panel Report are held. Selected Conferences, Symposia or Workshops are sponsored and supported where the subject involved is of major importance to NASA and interfaces strongly with its materials and structures technology program. Support is sometimes shared with other agencies and/or industry.

**W77-70007** **505-01-34**
Langley Research Center, Langley Station, Va.
**COMPOSITES AND ADHESIVES**
R. R. Heldenfels 804-827-2042
(505-02-41; 506-17-21; 524-71-01; 743-01-22)

The objective is to develop new or improved lightweight polymeric composite and metallic materials that have longer lifetimes, greater reliability and improved structural efficiency in aeronautical structures. The work will consist of research aimed at improvement of structural resins and adhesives through systematic variation in the polymer molecular structure, determination of behavior of new or advanced filamentary composite materials containing either resin or metal matrices, and development of new or improved fabrication methods for metal-matrix and resin-matrix composite materials. Research will also be directed at repair technology of composites including detection of flaws, determination of critical flaw sizes, development of appropriate repair procedures, and evaluation of the effectiveness of the repairs on composite behavior. Studies of interfacial reactions and diffusion processes in advanced metal-matrix composites with emphasis on degradation as a function of temperature, stress and environmental corrosion will also be made. An additional objective is to study, with the aim to alleviate, moisture effects on polymer matrix composites and adhesive joints. These studies will help to identify new or advanced materials and processes for aeronautical structural applications and will provide important data on the behavior, capabilities and limitation of such materials.

**W77-70008** **505-01-34**
Lewis Research Center, Cleveland, Ohio.
**COMPOSITES**
T. T. Serafini 216-433-4000

The overall objective of this research is to develop metal matrix and polymer matrix composite materials with improved properties and processing characteristics for use in fabricating various aeronautical propulsion structural components. Recent cost-benefit studies show that the use of fiber reinforced composites in turbofan engines can provide significantly improved performance resulting in reduced fuel consumption and operating costs. Composites being considered include resin matrices reinforced with graphite, boron, Kevlar, and glass fiber, and aluminum and titanium matrices reinforced with boron and SiC fibers. In the metal matrix work, emphasis is placed on the development of fabrication processes and the improvement of impact resistance. In the area of polymer matrix composites, emphasis is given to developing moisture resistant resins, processable high temperature resins, fire resistant composites, low cost fabrication methods and correlating NDE measurements with mechanical properties. Emphasis will also be placed on achieving a basic understanding of the chemistry and molecular structure-to-property relations for the various polymers being considered for use as matrix materials and also for graphite fibers.

**W77-70009** **505-02-12**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**HYPERSONIC VEHICLE STRUCTURES TECHNOLOGY**
R. A. Fields 805-258-3311

The resources of this RTOP are used to investigate flight loads measuring problems anticipated in the hypersonic flight environment. A resulting fallout of this effort will be information validating advanced structural concepts utilizing the hot, radiating structure approach.

**W77-70010** **505-02-12**
Langley Research Center, Langley Station, Va.
**HYPERSONIC VEHICLE STRUCTURES**
R. R. Heldenfels 804-827-2042
(516-56-10; 506-17-22)

Explore thermal/structural concepts for future hypersonic aircraft, and derive analysis and design methods applicable to such concepts. Research and development is being carried out to establish a technology base from which the structures and thermal control systems for hypersonic vehicles can be designed. Included in the program are both experimental and analytical efforts on airframe structure concepts which will withstand the rigors of extended and repeated use in a hypersonic environment. Research data obtained from both laboratory and wind tunnel experiments will serve to verify design and analysis methods, establish design guidelines, and provide guidance for future research efforts.

**W77-70011** **505-02-13**
Langley Research Center, Langley Station, Va.
**GENERAL AVIATION CRASHWORTHINESS**
R. R. Heldenfels 804-827-2042

The objective is to create and evaluate advanced structures concepts, develop technology for improving the crashworthiness of aircraft components, and derive analysis and design methods for aircraft structures. This RTOP is the NASA portion of a joint FAA/NASA General Aviation Crashworthiness Program to provide the analyst or designer with a proven analytical methodology for prediction of collapse of a structure under crash conditions. To achieve the objective, analytical and experimental studies will be performed to define the basic mechanisms involved in crash behavior. This technology, coupled with research on improved energy dissipation concepts will be applied to current general

aviation aircraft to evaluate potential improvements in survivability for specific crash envelopes. There are three basic areas of research in this program, full-scale crash simulation testing, nonlinear structural analyses necessary to predict total collapse of structures, and evaluation of energy absorption concepts for specific component design. Both analytical and experimental methods will be used to develop expertise in these three areas. Analyses will include both simplified procedures for estimating energy absorption capabilities and more complex computer programs for analysis of general airframe response. Under the crash program these analyses will be developed to provide the designer with methods for predicting accelerations, load, and displacment histories of collapsing structures. Fullscale tests of typical structures as well as tests on structural components will be used to verify the analyses and to demonstrate improved design concepts.

**W77-70012** **505-02-14**
Langley Research Center, Langley Station, Va.
**COMPUTER-AIDED DESIGN METHODS**
R. R. Heldenfels 804-827-2042
(506-17-21; 743-01-01; 743-01-11)

The objectives are to develop advanced computer-aided analysis and design methods for design of aircraft structures. Develop analysis techniques with the generality and efficiency required for the iterative calculations involved in sizing structural members. Develop and evaluate algorithms to accomplish structural sizing to meet constraints including strength, stiffness, aeroelasticity, thermal stresses, and minimum gage. Evaluate and define effective architecture of structural analysis and design systems and evolve specifications for the component technical computational modules in such systems.

**W77-70013** **505-02-21**
Ames Research Center, Moffett Field, Calif.
**UNSTEADY AERODYNAMIC LOADS AND AEROELASTICITY**
R. H. Petersen 415-965-6374
(505-06-11; 505-06-21)

The objective of this research is to provide improved prediction methods and data that apply to several unsteady aerodynamic load and aeroelasticity problems involving airplanes and helicopters. In the area of dynamic loads, available data will be analyzed and reported on the surface pressure fluctuations associated with overall aircraft buffet and local buffeting of structures which occurs in the vicinities of protuberances, cavities, and turrets on aircraft. An improved curved-surface aerodynamic paneling method will be developed for improved prediction of steady-state, gust, and active-control loads. With respect to aeroelasticity, both analytical and experimental investigations will be conducted to develop and validate computational methods for prediction of motion dependent unsteady aerodynamics. Experimental investigations of unsteady pressures on oscillating two-dimensional wings which are applicable to both airplanes and helicopters, will be conducted at transonic speeds.

**W77-70014** **505-02-21**
Langley Research Center, Langley Station, Va.
**LOADS, AEROELASTICITY AND STRUCTURAL DYNAMICS**
R. R. Heldenfels 804-827-2042

In order to predict flutter and other aeroelastic phenomena more accurately, research will be conducted to improve aeroelastic analysis methods, to provide accurate unsteady transonic aerodynamics, and to validate rotor dynamic analysis. In order to improve and validate aeroelastic loads analysis programs, various load prediction techniques (including FLEXSTAB) will be evaluated and improved for integration into computer systems such as ATLAS and IPAD. In order to develop methods for predicting acoustic loads, structural response, and noise transmission through aircraft structures, methods for analyzing panel response with a thick boundary layer will be developed and compared with experiment. Noise transmission through aircraft structures will be studied. The objective of these efforts is to provide the technology necessary to increase aircraft performance and extend service life and to improve aircraft safety and ride quality through improvements in methods for predicting loads, aeroelastic effects, and structural response.

**W77-70015** **505-02-22**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**DRONES FOR AERODYNAMIC AND STRUCTURAL TESTING (DAST)**
P. C. Loschke 805 258-3311
(505-11-24; 512-53-01)

Object DAST (Drones for Aerodynamics and Structural Testing) is a technology development program that will provide data that will lead to a better understanding of unsteady aerodynamic loads and flutter at transonic speeds. The program is a combined theoretical, wind-tunnel and flight-test activity and is a joint LaRC/FRC program. The flight-test activity is the subject of this RTOP. A Supercritical wing will be installed on a Firebee II. This wing will be at a planform representative of transport aircraft. The wing will be designed to be flutter critical within the normal flight envelope of the modified Firebee II. A system will be installed to provide the necessary flutter damping. The vehicle will be instrumented to measure wing pressures, accelerations, and strains. The RPRV system installed in the DAST vehicle will be similar to the system developed in the RPRV Capability Development program which will be completed mid FY-77.

**W77-70016** **505-02-22**
Langley Research Center, Langley Station, Va.
**DAST (DRONES FOR AERODYNAMIC AND STRUCTURAL TESTING)**
R. R. Heldenfels 804-827-2042
(516-53-01)

The objective is to provide the technology necessary to increase aircraft performance, fuel efficiency and extend service life, and to improve aircraft safety and ride quality, through improvements in methods for predicting loads, aeroelastic effects, and structural response. The approach will be to provide flight data for comparison with results from various prediction methods and for cases where analyses are known to be inadequate. Emphasis will be on measurements of transonic aerodynamic loads and flight demonstrations of active control systems for load alleviation and flutter suppression. Flight testing techniques will be developed using drone-type vehicles to gather the desired data. An aeroelastic research wing will be provided with its flutter boundary within the flight envelope when flown on a Firebee II vehicle. First flights will be aimed at measuring aerodynamic loads in the transonic range, then active control systems will be incorporated for flight assessments of their performance in alleviating loads and suppressing flutter. Flights will be made cooperatively with the Flight Research Center. Other wing designs and aeroelastic phenomena, focused on wind tunnel and flight test validation will be investigated, as deemed appropriate.

**W77-70017** **505-02-23**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**FLIGHT LOADS MEASUREMENT TECHNIQUES**
Jerry M. Jenkins 805-258-3311

General problems are being pursued through the resources of this RTOP. (1) Considerable progress has been made in the area of solving the fatigue sensitivity of titanium alloys when weldable strain gages are attached. This effort is nearing completion. (2) Work is continuing on examining the load calibration philosophies utilized on complex aircraft structures. (3) Work is beginning on the problems associated with strain gage calibration of composite structures and the fatigue sensitivity of berylium alloys to strain gage installations.

**W77-70018** **505-02-25**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**B-1 FLIGHT LOAD MEASUREMENT RESEARCH**
Alan L. Carter 805-258-3311

The objectives of this research area are to evaluate airload measurement techniques on large flexible aircraft, to evaluate newly developed computer programs for aeroelastic analysis, and

to examine the dynamic response and structural mode control system. This effort will be a joint NASA-Contractor Program.

**W77-70019** **505-02-31**
Langley Research Center, Langley Station, Va.
**FATIGUE AND FRACTURE**
R. R. Heldenfels 804-827-2042
(506-17-27; 743-01-01)

The objective is to develop design methods to insure long and reliable crack-free service in efficient aerospace structures and enhance the resistance to flaws in such structures by damage tolerant design procedures. Existing design methods are evaluated critically, new methods are developed where needed and verified by experiment, and computerized design modules are developed whereby design compromises can most intelligently be made. Specific goals are to develop a fatigue life prediction scheme based upon calculations of local stress-strain histories at critical points of metallic structures subjected to simulated service loadings and temperatures, test a composite box beam that simulates the structural features typically found in operational airframes, and determine the effects of repeated biaxial loads on the fatigue life of composite structural materials.

**W77-70020** **505-02-41**
Langley Research Center, Langley Station, Va.
**COMPOSITE MATERIALS APPLICATION TO AIRCRAFT STRUCTURES**
R. R. Heldenfels 804-827-2042
(505-01-34; 510-51-01; 743-01-22; 734-01-01)

The objectives are to conduct research on composite materials to resolve problems that may hinder their application, to develop the technology required for their utilization in future aircraft structures, and to establish confidence in the use of composites through longtime flight service of structural components on commercial transport aircraft and Army helicopters. The work consists of the following: development of analytical methods to improve understanding of composite materials; evaluate bahavior under various environmental conditions; develop concepts, fabrication, and nondestructive evaluation technology, fabrication and test of critical components to demonstrate performance, conduction of engineering studies to determine applicability of composites in primary or secondary structures of commercial or military aircraft, establishment of repair techniques for flawed or damaged structure. Development of applications to operational aircraft such as the CH-54B helicopter, 737, L-1011, and DC-10 commercial transports.

**W77-70021** **505-02-42**
Langley Research Center, Langley Station, Va.
**DESIGN TECHNOLOGY FOR COMPOSITE STRUCTURES**
R. R. Heldenfels 804-827-2042
(506-17-26)

The objective is to advance the technology of filamentary composite structures which will provide the potential of a 25% weight reduction by conducting analytical and experimental laboratory investigations of selected components. Advanced methods of predicting the strength and stability of laminates, panels and stiffened components, including the effects of damage, will be applied to new test data. Analysis will be applied to define the limitations of conventional test methods and to develop more satisfactory test methods. Development fo a strong in-house program for design and test of aircraft components will be continued. Designs for wing compression covers will be developed using advanced methods. A large number of graphite panels with either open or closed sections will be designed. Fabrication and test in the LaRC Structures Laboratory. Effort will include industry-developed as well as NASA-developed designs. Data will be generated over a large range of loading to provide a substantial NACA-type data bank upon which to base designs. A parallel program for wing shear webs will be continued. Optimum design curves will be developed over a wide loading range for both sandwich and stiffened shear web design. Maximum strength of large graphite webs will be determined in a series of tests at Langley.

**W77-70022** **505-02-43**
Lewis Research Center, Cleveland, Ohio.
**COMPOSITE FAN BLADES AND ENGINE STRUCTURES**
R H. Johns 216-433-4000

The general objective of this program is to develop the structures technology required to provide foreign-object-damage (FOD) resistant composite fan blades and blade containment components. Fibers being considered include graphite, boron, Kevlar, and glass; matrix materials considered include epoxy, polyimide, and aluminum. Hybrid and superhybrid composite concepts will continue to be developed to maximize the impact resistance for satisfying foreign object damage requirements. Combinations of fibers, orientations of multiple laminates, and fabrication techniques will be evaluated to maximize toughness consistent with other design requirements such as strength and aeroelastic response. The environmental effects on impact resistance correlations between composite properties and impact resistance will be established. Static impact testing and single blade whirling arm rig tests are being used to compare and evaluate different concepts and assure adequacy of final design and materials selection for both composite fan blades and containment structures. (Scope change- initiate work with blade containment components.)

**W77-70023** **505-02-44**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ADVANCED COMPOSITE MATERIALS TECHNOLOGY FOR AUTOMOTIVE APPLICATIONS**
G. W. Meisenholder 213-354-4058

The perfromance benefits resulting from application of advanced composite materials to aircraft structures are offset by the high costs of these materials. These costs could be reduced significantly by a major increase in production volume of composites. Such increase can be achieved if composites could be applied to automotive vehicles. JPL will explore this potential by performing a comprehensive technical, economic, and institutional study. This detailed study will include: (a) technical and economic analysis of designs of candidate elements (components and/or subassemblies thereof) in composite technology visa-a-vis a moving baseline of their counterparts in conventional automotive materials; and (b) analysis of both the automotive and materials-producing industry impacts associated with their introduction. A key consideration is maximum credibility of results to all parties at interest. JPL's expertise in automotive system studies will be augmented by direct involvement of an Automotive Industry Participant and materials supply industry consultants, plus the considerable experience of other NASA centers and the AFML. This RTOP describes the total study program, including an initial Phase Zero activity. In the Phase Zero effort, a more detailed planning of the program proper, and the requisite interfacing with industry and other NASA centers, will be accomplished. The cost ($90K) and schedule (5 mo.) for the Phase Zero effort are firm. Cost and schedule for total program, also included herin, will be refined and finalized in the course of Phase Zero.

**W77-70024** **505-03-11**
Lewis Research Center, Cleveland, Ohio.
**BASIC NOISE RESEARCH**
E. W. Conrad 216-433-4000
(505-03-12)

This RTOP covers work directed toward understanding the basic principles and phenomena involved in the generation, propagation and suppression of turbomachinery, jet, jet-surface interaction, and core noise. The work combines in-house analytical and experimental studies with a number of university type grants and contracts to form a coordinated basic noise research program that is structured to permit aeroacoustic specialists to carry out investigations of several years duration, if appropriate. The work is directed toward providing a broad base of understanding and knowledge of the various noise areas through fundamental, analytical and experimental studies. This foundation will provide a fundamental base for reducing aircraft propulsion generated noise with minimum weight, performance, and economic penalties.

**W77-70025** **505-03-11**
Langley Research Center, Langley Station, Va.
**NOISE REDUCTION TECHNOLOGY**
R. R. Heldenfels 804-827-2042
(505-03-21; 504-09-11; 505-06-23)

The objective of this research is to provide a data and technology base for reducing aircraft propulsion generated noise with minimum weight, performance, and economic penalties. Included in this objective is the identification and location of sound sources in flow fields, and in situations where aerodynamic flows interact with surfaces; atmospheric propagation including refraction and scattering; the improved efficiency of acoustic suppression materials and treatment technology; and improved data acquisition and analysis equipment and methods. Both theoretical and experimental studies are involved and work will be accomplished in-house and by grants and contracts. The effects of forward motion will be evaluated on the noise from jet exhausts and inlets by means of quiet wind tunnels, high-speed ground vehicles and by selected aircraft flight measurements. The effects of the atmosphere on noise propagation will be studied using instrumented towers and outdoor instrumented ranges to correlate acoustic and atmospheric phenomena. This work will also include precision measurements and calculations of the sound fields inside finite ducts with airflow, with varying cross sectional areas, and with and without acoustic treatment materials. Emphasis in the experimental portion of the program is on laboratory and scale-model experiments under closely controlled conditions for validating theoretical methods and concepts.

**W77-70026** **505-03-11**
Jet Propulsion Lab. Calif. Inst. of Tech., Pasadena
**BASIC NOISE RESEARCH**
R. R. McDonald 213-354-6186

The general objectives of this RTOP are; (1) to find methods of reducing jet noise by controlling the shear noise sources and by destructive interference, (2) to determine how core flow disturbances increase the radiated noise from jets with the ultimate goal of developing efficient means of reducing jet noise emission by reducing core flow disturbances, (3) to develop a prediction model for evaluating forward flight effects on jet and core noise based on experiments, (4) to develop and evaluate methods of reducing jet noise for aircraft in flight, and (5) to complete the studies for evaluating the effect of temperature on jet noise. Experiments of supersonic, subsonic and coannular jets over a temperatue range up to about 2000 F are conducted in an aneochoic chamber. The turbulent eddies are characterized in terms of cross-correlations of the fluctuating density obtained from the detected signals of cross-laser beams set up as a schlieren system. Additional fluctuating quantities are measured with hot-wire probes. The effects of core flow disturbances which will be examined are entropy fluctuation interactions. These interactions will be induced by introducing temperature and pressure fluctuations into the plenum located upstream of the nozzle. Spectral intensity of the radiated noise will be compared with the induced fluctuations. Flow oscillations induced with the use of cavities will also be investigated as a means of destructive interference of tones generated by upstream sources, such as those caused by turbines and fans. Cavities will also be used to excite shear layer instabilities. This may lead to reduction of jet noise by destructive interference when two jets are located side by side as on the wing of an airplane. In addition, cavities located on the outer surface of a simulated cowl and protuberances on the inner surface will be investigated. It is believed that by thinning the boundary layer by these methods a reduction in radiated noise will occur in flight.

**W77-70027** **505-03-12**
Lewis Research Center, Cleveland, Ohio.
**NOISE REDUCTION TECHNOLOGY**
E. W. Conrad 216-433-4000
(505-03-11)

The objective is to provide data and a technology base directed toward improved understanding of noise generation mechanisms and improved correlation and prediction techniques for reducing aircraft propulsion noise with minimum weight, performance and economic penalties. Research is performed on fan, core and combustion noise generation and its suppression and shielding. Fan noise research will continue in the 20-inch model rig in W-2 as well as by contract. Hardware incorporating several acoustic parameters (such as reduced fluctuating stator lift, reduction of MPT's in transonic and supersonic fans by means of shock swallowing and shockless rotor blades, reduced rotor stator interaction, and boundary layer bleed) is on hand or about to arrive and will be evaluated. An ultrahigh flow supersonic fan design is completed and will be fabricated. Work will begin toward a fan assembly intended to reduce noise due to rotor vortices intersecting the stator assembly. Core and combustion noise research will be conducted to determine internal near field and far-field noise spectra. Jet noise generation and methods of shielding jet noise will be examined. Forward velocity effects on STOL engine-over-the-wing configurations will be evaluated. New ideas for noise generation mechanisms, reduction, suppression and measurement will be investigated, and improved correlation and prediction techniques will be established.

**W77-70028** **505-03-12**
Ames Research Center, Moffett Field, Calif.
**NOISE REDUCTION TECHNOLOGY**
Leonard Roberts 415-965-5066
(505-10-41)

The primary objective is to provide noise technology for short haul aircraft. This includes the study and reduction of noise from jet turbulence mixing, fan machinery noise, and propulsive lift noise. The program will be particularly oriented to large scale studies and studies of flight effects on noise using the proven capability of the Ames 40- by 80-Foot Wind Tunnel. An additional objective is to define flight effects on noise from an SST Phase II Suppressor at the request of the SCAR program office. The program proposed for FY 1977 will continue to investigate the effect of forward speed on jet mixing noise, completion of the study on the effect of swirl on jet mixing noise and the coupling mechanisms between core, combustion and mixing noises, and continued study of the effect of forward speed on fan noise. This experimental research will be conducted on full-scale engines. Theoretical analyses of the turbulence structure and noise producing characteristics of swirling jets will be concluded. The major new element for FY 1977 is a forward speed effects study of a JT8D engine with a flow inverter type suppressor.

**W77-70029** **505-03-13**
Langley Research Center, Langley Station, Va.
**GENERAL AVIATION NOISE REDUCTION**
R. R. Heldenfels 804-827-2042
(505-03-11)

The objectives of this research are to develop and demonstrate advanced noise reduction technology for general aviation to meet published noise standards with minimum performance penalty and without degrading flight safety; and to develop a more complete understanding of propeller/propulsor noise mechanisms that will provide for aero/acoustic design prediction methodology for the evaluation and demonstration of noise reduction techniques. Theoretical and experimental studies will be undertaken in-house and under contract. Flight and wind-tunnel experiments will be undertaken with a specially instrumented propeller in order to relate the noise radiation to fluctuating pressure measurements on the blade surface as part of a general theory of noise generation. Other experiments involve wind-tunnel tests of acoustically designed shrouded propulsors, performance designed propellers, and the documentation of the noise signatures of typical general aviation aircraft, identifying the separate noise source contributions of the propeller and power plant.

**W77-70030** **505-03-21**
Langley Research Center, Langley Station, Va.
**NOISE FOOTPRINT PREDICTION**
R. R. Heldenfels 804-827-2042

The objective of this work is to develop and verify an integrated, state-of-the-art Aircraft Noise Prediction Program (ANOPP). A wide range of activities is being undertaken to assure that the most advanced, yet widely accepted, prediction methods are implemented. The areas of flyover noise measurement-noise

data reduction techniques, airport and aircraft operating procedures, data base maintenance, component noise sources and source noise modeling, shielding, reflection, propagation, and computer sciences will be continuously reviewed and updated.

**W77-70031** **505-03-21**
Lewis Research Center, Cleveland, Ohio.
**NOISE FOOTPRINT PREDICTION**
F. J. Montegani 216-433-4000

Based on theoretical and experimental knowledge of aircraft component source noise and noise propagation, noise prediction models are formulated for incorporation into the NASA Aircraft Noise Prediction Program being developed at Langley Research Center for noise footprint prediction. The specific aircraft noise areas of major technical effort are: fan, jet, combustor, turbine, flap, duct acoustics, and propagation. The noise prediction models are formally documented in NASA publications. Those research areas critical to the improvement of noise prediction are identified and specific research programs to obtain the improvements are suggested. The work is structured to permit convenient validation, improvement and updating of the prediction models as additional information is developed.

**W77-70032** **505-03-31**
Langley Research Center, Langley Station, Va.
**BASIC POLLUTION RESEARCH**
P. F. Holloway 804-827-2893

The objectives of this reserach are the following: (a) to develop a chemical kinetic model that describes the combustion of a jet fuel and the formation of nitric oxide by the systematic study of the combustion mechanisms, reaction kinetics, and nitric-oxide formation kinetics for increasingly complex hydrocarbon fuels; (b) to obtain fundamental data on the formation and burnout of soot in a flatflame (propane) burner using a laser light-scattering technique; (c) to experimentally investigate the effect of fuel structure and composition on the optical properties of flame-generated soot. The facilities used in these studies include a chemical shock tube a jet-stirred combustor, and a high-pressure burner.

**W77-70033** **505-03-32**
Lewis Research Center, Cleveland, Ohio.
**GAS TURBINE ENGINE POLLUTION REDUCTION TECHNOLOGY**
R. A. Rudey 216-433-4000
(743-03-21; 505-04-31)

The objective is to develop, evaluate, and demonstrate the technology required to reduce modern gas turbine aircraft engine exhaust emission pollutants to levels complying with current and future environmental air quality standards with minimum adverse effects on performance, weight and complexity. Various techniques for reducing pollutant emissions are being investigated both in-house and under contract in full-scale combustor rigs, combustor segment rigs, and basic flame-tube type rigs. Five major multi-phased contract efforts are being used to develop and demonstrate, in modern aircraft engines, advanced combustor concepts that are aimed at reducing the pollutant emissions to levels equal to or less than those established by the EPA for engines manufactured after 1979. These programs include candidate engines from all designated classes covered by the EPA Standards for civil aviation aircraft. In-house and contract efforts to explore high pressure-high temperature advanced combustor designs, fundamental modeling and combustion pollutant formation studies, identification of odorants, and non-invasive measurement techniques are also being conducted. Studies initiated in FY-76 to provide fundamental knowledge on extremely lean combustion concepts are being consolidated into a new RTOP (511-55).

**W77-70034** **505-03-32**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GAS TURBINE ENGINE POLLUTION REDUCTION TECHNOLOGY**
R. R. McDonald 213-354-6186

New (unconventional) combustor design concepts for application to aircraft gas turbines are being evaluated for their potential for providing significantly reduced pollutant emissions. Reducing oxides of nitrogen while maintaining efficient, clean combustion is emphasized. The central conceptual approach is to minimize NO formation rates by reducing flame temperature and by promoting off-stoichiometric burning. A continuing objective for FY-TR/77 is the demonstration of feasibility of implementing the H2-enrichment concept to provide for very lean combustion of H2/JP fuel mixtures. Primary emphasis is placed on establishing an experimental burner configuration that demonstrates stable, high efficiency combustion with low pollutant emissions over a range of inlet air conditions typical of contemporary, high performance turbine engines. Providing that concept feasibility is demonstrated using bottled-H2, a second objective is to commence exploratory experiments on the feasibility of incorporating a partial oxidation reaction zone to generate the required H2. A continuing objective is the establishment of design criteria for implementing the H2-enrichment concept in practical combustion systems for aircraft turbine engines.

**W77-70035** **505-03-33**
Lewis Research Center, Cleveland, Ohio.
**GENERAL AVIATION INTERNAL COMBUSTION ENGINE POLLUTION REDUCTION**
William T. Wintucky 216-433-4000
(505-05-51; 505-05-52)

The objective is to establish and demonstrate by 1979 the technology necessary to safely reduce general aviation intermittent combustion engine exhaust emissions to the levels required by the 1979 emissions standards with minimum adverse effects on cost, weight, fuel economy, and performance. A joint FAA/NASA program with the engine manufacturers is under way to establish emission levels of current general aviation piston engines and investigate minor engine modifications to safely reduce emissions to meet EPA 1979 standards. A comprehensive program comprising contract work by the engine manufacturers as well as a Lewis Research Center in-house technology effort has been established. Work performed under contract with the engine manufacturers is directed to establishing near-term solutions while inhouse work is concentrated on longer-term solutions requiring additional analytical and experimental technology required to meet emission standards.

**W77-70036** **505-03-41**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**ATMOSPERIC EMISSION INTERACTION TECHNOLOGY (MINI-SNIFFER)**
Robert D. Reed 805-258-3311

The objective of this RTOP is to develop a small remote piloted sampling vehicle (Mini-Sniffer) capable of encountering and sensing both natural and man-made atmospheric contaminates and fine turbulence in the altitude range from 50,000 to 100,000 feet. Since the vehicle will fly to low expected speed it will provide precise positioning and maneuvering in the segmented atmospheric pollution concentrations at these altitudes as well as defining the basic fine atmospheric turbulence characteristics at these altitudes. The Mini-Sniffer is the only stratospheric sampling platform that can gather both fine turbulence data in aircraft wakes as well as ambient atmospheric data (gust velocities less than 0.1 foot per second and wave lengths less than 200 feet) in horizontal and vertical surveys. The design target is to develop an inexpensive vehicle and an operational technique requiring only a one or two-man crew to operate in addition to radar and payload support personnel.

**W77-70037** **505-04-11**
Ames Research Center, Moffett Field, Calif.
**V/STOL AIRCRAFT AND PROPULSION SYSTEM INTEGRATION**
Richard H. Petersen 415-965-5881
(505-06-15; 505-06-11; 505-10-43)

The new emphasis on this RTOP will reflect the areas of emphasis assigned to Ames Research Center in short haul and V/STOL aircraft. This RTOP will emphasize the airframe-propulsion integration on aircraft applicable to Navy operations from small ships. The program will focus on the development of prediction techniques capable of assessing the propulsion installation effects.

Several V/STOL propulsion configurations will be studied and the most promising selected to serve as a basis for the development of analytical methods in combination with wind tunnel testing. Existing work on laser diffusers, variable cycle engines, and inlet distortion will be completed during FY-76TQ in accordance with ARC areas of emphasis.

**W77-70038** **505-04-11**
Langley Research Center, Langley Station, Va.
**INLETS AND NOZZLES**
R. E. Bower 804-827-3285

Studies of locations of the engine power plant in various positions on the airframe will be conducted in order to achieve better integration with the airframe and to exploit any favorable interference effects which may enhance the wing lift, performance efficiency, reduce drag or permit vectoring of the exhaust to improve performance and control of the aircraft. For the exhaust nozzle, investigations will be made to determine means of improving the internal and external performance of both unir stalled and installed nozzles and to explore the integration procedures for incorporating the exhaust system into the fuselage, wing or pods. General experimental and theoretical research studies will be conducted to improve the understanding of the flow phenomena associated with inlet/boattail/jet and jet/wing/airframe empennage interference. Experimental research on axi and nonaxisymmetric nacelles will be conducted for correlation with analytical results and design procedures will be developed from this information.

**W77-70039** **505-04-11**
Lewis Research Center, Cleveland, Ohio.
**INLET AND NOZZLE TECHNOLOGY**
D. N. Bowditch 216-433-4000

Improved analytical and experimental design methodology for inlets and nozzles will be generated to achieve higher performance with increased propulsion system stability. Computer analysis programs for predicting both internal and external flows will be synthesized in-house and by contracts and grants. These programs will make it possible to analyze combined viscous and inviscid flows in two and three-dimensions. Inlets and nozzles will be tested for comparison with theory and to provide design trade information for optimization of aircraft configurations. The compatibility of the inlet and nozzle with the turbine engine and airframe will be investigated to develop inlet-engine-nozzle compatibility methodology. Experimental testing will take place in 10x10, 8x6, on the F106 aircraft and in a static thrust stand, CE 22.

**W77-70040** **505-04-21**
Lewis Research Center, Cleveland, Ohio.
**FAN AND COMPRESSOR TECHNOLOGY**
M. J. Hartmann 216-433-4000
(511-51-01)

Approaches to improve efficiency, operating range distortion tolerance, durability and reliability and to reduce weight, volume and cost of the wide variety of fans and compressors required for advanced propulsion systems will be investigated. Analytical methods to improve accuracy of performance prediction to reduce the time, cost and risk of incorporating advanced fans and compressors into future engine development programs will be developed and compared to experimental data obtained in advanced single and multistage compressors. Both in-house and contract efforts are required. The major program thrusts are to: (1) extend fan stage pressure ratio (2) improve fan performance with low noise design and devices (3) evolve design/analytical/evaluation method (4) improve performance retention (5) determine matching requirements of high pressure stages (6) extend core stage pressure ratio, and (7) improve performance of small centrifugal compressors.

**W77-70041** **505-04-22**
Lewis Research Center, Cleveland, Ohio.
**TURBINE TECHNOLOGY**
H. E. Rohlik 216-433-4000

The turbine program includes experimental and analytical research in turbine cooling and turbine aerodynamics. Contract and in-house studies are being made of this basic fluid behavior in flow channels, boundary layers, and coolant passages in blades, disks, and endwalls. The applications being considered range from large aircraft and ground power generation turbines down to small axial and radial turbines for helicopter and automobile engines. Advanced engines for future commercial and military missions may employ temperatures higher than 1800k and pressures of 30 to 40 atmospheres. The severe cooling requirements have led to studies of convection, impingement, and full-film cooling as well as the use of ceramic thermal barrier coatings. The aerodynamic effects of the kind and amount of coolant injected into the main flow are being studied simultaneously. Closed and open water cooling systems, with and without auxiliary helium loops, are being examined for stationary ground power systems. In addition, investigations are being made of multistage turbines with work factors from 3 to 5 for application in high bypass ratio lift and cruise engines.

**W77-70042** **505-04-23**
Lewis Research Center, Cleveland, Ohio.
**PROPULSION INSTRUMENTATION**
N. C. Wenger 216-433-4000

Present efforts in propulsion research are often limited by the inability to make rapid and precise measurements of the parameters of interest. Rapid advances in propulsion technology have in many cases pushed conventional instrumentation techniques to their limits. Further work on improving conventional instrumentation and measurement techniques will probably result in only incremental improvements. The objective of this RTOP is to expand the instrumentation technology base and to explore new concepts that have the potential for significantly advancing present measurement capabilities. Particular emphasis will be palaced on six critical areas that have been identified as serious impediments to full scale engine and component testing. They are: (1) turbine blade temperature measurement; (2) gas temperature measurement; (3) gas flow measurement; (4) blade tip clearance measurement; (5) blade flutter measurement; and (6) rotary instrumentation systems. New and improved measurement concepts and techniques in each of the six areas will be explored with each study culminating in an experimental demonstration of a prototype instrument or system.

**W77-70043** **505-04-31**
Lewis Research Center, Cleveland, Ohio.
**COMBUSTION AND AUGMENTATION SYSTEMS TECHNOLOGY**
R. A. Rudey 216-294-6160
(505-03-32)

The objective is to establish the technology necessary for combustors and augmentors to achieve high performance and good durability at operating conditions typical of advanced commercial and military gas turbine engines. A swirl-can combustor is being developed for use in the High Pressure Facility (HPF) both as a heat source combustor for the turbine rig and also as a research combustor. A variety of new combustor concepts will be investigated; first in a sector rig at low pressure, then further refined in design and tested as full annular designs in ECRL-1 at pressures up to 120 psi, and finally tested in HPF at pressures up to 580 psia. This effort will be supported by research in liner film-cooling, jet penetration and mixing, fuel injection, vaporization and premixing, premixed fuel autoignition and various diffuser and cold flow model tests. Several designs of small combustors of the reverse flow and axial flow types will be designed and tested for performance and emission characteristics. The augmentor program to study ways of improving augmentor performance of turbofan engines by investigating a variety of new design approaches was completed.

**W77-70044** **505-04-41**
Lewis Research Center, Cleveland, Ohio.
**DRIVE SYSTEM MECHANICAL COMPONENTS TECHNOLOGY**
W. J. Anderson 216-433-4000
(506-16-22; 511-54-01)

The objective of this work is to advance the technology for bearings, shaft seals, gas path seals, gears, shafts, lubricants,

lubrication systems and mechanical power transmissions to achieve increased effectiveness, life, reliability, efficiency, and low weight in the high temperature, high pressure, and high speed environments of turbofan and turbo-propeller engines, and mechanical power transmission systems. Basic materials development, design theory, lubrication techniques, analysis and experimentation will be performed for extreme conditions with lubricants, lubrication systems, bearings, seals and gears of advanced aircraft turbojet and turbo-propeller engines to achieve efficient performance, reliability and extended life. Analytical techniques for balancing, determining and controlling the dynamic behavior of shafts and rotors will be developed and corroborated experimentally to provide better design tools for high-speed turbomachinery, shafting and transmissions. New transmission concepts will be developed.

**W77-70045** **505-04-51**
Lewis Research Center, Cleveland, Ohio.
**FUELS TECHNOLOGY**
R. A. Rudey 216-294-6160

The potential properties of future aviation turbine fuels derived from nonpetroleum sources such as oil shale and coal will be determined by synthesis and characterization techniques both in-house and under contract. The effects of these fuels, as well as petroleum based fuels synthesized to broader specifications than currently required, on the performance and durability of jet engine components and materials will be determined through in-house and contract studies. Sufficient quantities of these fuels must be procured and/or simulated by blending of petroleum based fuels and will be used to conduct research tests required to evolve the technology that may be needed to use these fuels in current and future jet aircraft engines. A joint program has been developed with the AFAPL and Lewis to implement an overall integrated effort to best utilize the technical capabilities of the AFAPL and Lewis to conduct the various activities necessary in conducting this program. Cooperative efforts on contract funding and management, and in-house test activities are currently underway and will be used throughout the planned life of this program. Overall coordination with other government agencies, such as the USN, EPA, and with industry will also be maintained in order to provide proper direction and scope to the program as it develops and proceeds.

**W77-70046** **505-05-11**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**DYNAMIC BEHAVIOR AND CONTROL TECHNOLOGY**
W. D. Painter 805-258-3311

The objective of this effort was to flight test an integrated propulsion control system (IPCS) on and F-111E airplane. The IPCS program objectives were to: (1) demonstrate the control of a state-of-the-art propulsion system using a digital computer and associated interface equipment, (2) evaluate the improvement in steady-state and transient propulsion system performance due to IPCS, and (3) evaluate the changes in compatibility between the engine and inlet, (stall margin change). This was a joint USAF/NASA Program in accordance with the Memorandum of Understanding dated September 6, 1972. The IPCS was designed and fabricated by the Boeing Company under a contract from the USAF.

**W77-70047** **505-05-11**
Lewis Research Center, Cleveland, Ohio.
**DYNAMIC BEHAVIOR AND CONTROL**
D. I. Drain 216-433-4000

The objective is to improve the understanding of and prediction of propulsion system dynamic behavior so that the system can be controlled at maximum performance. Furthermore, the control of the system must be able to accommodate sudden and unexpected disturbances safely and reliably. The approach is to apply the methods of dynamic analysis and simulation to establish the characteristics of airbreathing propulsion systems. Control theories and concepts will be developed and applied to achieve improved performance and operation of the system. Special control hardware, such as servos, instruments, and actuators, will be developed as required. Experiments with components and complete systems will be performed to validate the methods anc concepts developed for improved propulsion system control.

**W77-70048** **505-05-21**
Lewis Research Center, Cleveland, Ohio.
**ENGINE TECHNOLOGY**
Ross Willoh 216-294-6624

The objective of this program is to provide an improved technology base for future engine system development. Experimental and analytical efforts are undertaken to acquire understanding and to improve the technology base for the various technical disciplines associated with the detailed behavior, both dynamic and steady state, of the complete engine system. The objectives will be accomplished through research sub-programs on advanced subsonic and supersonic civil and military engines. Particular emphasis will be placed on seeking understanding and solutions for the dynamic interaction problems encountered when engine components are combined to form an engine system. The sub-programs will include investigations in areas such as aeromechanical instability, fan and compressor performance, inlet distortion, engine dynamics and controls, and the performance of various components. The overall program is primarily concerned with significant technical areas where large discrepancies exist between theory and actual performance. Engines currently in the program include J85-13, J85-21, TF30 and the F-100.

**W77-70049** **505-05-22**
Lewis Research Center, Cleveland, Ohio
**POWERED LIFT ENGINE TECHNOLOGY**
Carl C. Ciepluch 216-433-4000
(738-01-01; 505-02-43)

The objective of this RTOP is to advance the technology related to understanding the interactions between the engine, nacelle and airplane for powered-lift propulsion systems. The particular interactions to be studied include the nacelle, including inlet and exhaust nozzle, reverse thrust configuration and the wing/ flap configuration. Both aerodynamic and acoustic interactions will be studied. In addition, technology will be developed for fans, ejectors, and propulsion/aircraft interaction effects studied for thrusters for VTOL aircraft systems. The desired technology will be brought forth through analytical model development and test programs using models, components, engines and engine, nacelle and wing systems as required.

**W77-70050** **505-05-25**
Lewis Research Center, Cleveland, Ohio.
**PROPULSION SYSTEM INTERACTIONS TECHNOLOGY**
R. E. Coltrin 216-433-4000
(505-04-11)

The objective is to assess and improve test techniques and distortion methodologies used to predict inlet engine compatibility for highly maneuverable and cruise aircraft. The propulsion system interaction data bank obtained during the development of the b-1 aircraft will be the basis for the study. The effort will be accomplished through contracts with Rockwell International.

**W77-70051** **505-05-41**
Langley Research Center, Langley Station, Va.
**HYPERSONIC PROPULSION TECHNOLOGY**
R. E. Bower 804-827-3285

The program is aimed at the development of concepts for airframe-integrated, airbreathing propulsion systems to operate at speeds from Mach 3 to 10. Theoretical and experimental studies are conducted in fuel injection, supersonic combustion, and 3-D turbulent reacting flows in ducts of complex geometry having lateral pressure gradients in order to advance prediction and design techniques. Component investigations are conducted in-house with Langley facilities on inlet, combustor, and nozzle designs for modular scramjet engines. Performance and design optimization tests are performed with complete but subscale, boiler-plate type engine models at Mach 7 conditions in the Langley Scramjet Facility. Equipment received from Lewis Plumbrook is being installed in an existing Langley Propulsion Test Cell to provide a capability for test of complete, subscale scramjet engine models at Mach 4. The in-house program is augmented in several areas by R and D grants and contracts.

Design studies are conducted both in-house and under contract on flight-weight, fuel-cooled engine structures and systems. This program is focused on definition of a lightweight, fixed geometry, airframe-integrated scramjet engine module using a dual mode of H2 fuel injection to control mixing and combustion for a wide range of flight speeds. This engine technology will be capable of providing efficient propulsion for either cruise aircraft, accelerating and maneuvering aircraft, or with hydrocarbon fuel, high-speed highly maneuverable missiles.

**W77-70052** **505-05-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**HYDROGEN ENRICHMENT FOR AIRCRAFT PISTON ENGINES**
R. R. McDonald 213-354-6186

Analytical and experimental investigations of the potential for hydrogen-enriched fuels achieving significant reductions in fuel consumption while simultaneously reducing pollutant emissions in conventional aircraft piston engines will be conducted. Analytical representations of both supercharged and normally aspirated engine systems including all components required for on-board hydrogen generation will be formalized as a means for estimating changes in aircraft system efficiency and aircraft operating envelope. The performance improvements indicated by these estimates will be verified in a series of laboratory experiments on a selected aircraft engine type utilizing currently available hydrogen generators as separate laboratory components. The performance of these generators will be verified with aircraft type fuels prior to integration into the laboratory system. The estimated impacts on aircraft performance will be verified by flight testing the selected engine type in an aircraft which normally uses that engine (as unmodified). Aircraft/engine modifications will be limited to those minimum changes commensurate with a definitive experiment, an integral-with-engine hydrogen generator, and aircraft safety. A cooperative effort between NASA and cost-sharing industrial contractors is contemplated.

**W77-70053** **505-05-52**
Lewis Research Center, Cleveland, Ohio.
**GENERAL AVIATION ENGINE CONCEPTS**
William A. Tomazic 216-433-4000
(505-03-33)

The overall objective of this program is to meet or surpass the general aviation emission standards scheduled to go into effect at the end of 1979 while maintaining or improving upon current performance, reliability, fuel consumption, etc. Two approaches are proposed: (1) improving present engines and (2) accelerating the development of advanced engine concepts for future use. The specific goals of this program are supported by contracts, grants, and by LeRC in-house activities.

**W77-70054** **505-05-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**MONOLITHIC CATALYSTS FOR AIRCRAFT HYDROGEN GENERATORS**
R. R. McDonald 213-354-6186
(505-05-51; 778-17-02)

An on-board hydrogen generator has been built for an aircraft piston engine as part of RTOP 505-05-51. This generator uses a catalyst bed containing 1/8 inch pellets. Recently a new type of catalyst form has been developed in the automotive emissions area, namely the monolithic catalyst. Monolithic catalyst beds have several advantages over pellets, an important one being its considerably greater structural strength. Thermal cycling of pellets causes powdering of some pellets to produce 'fines' with time. This process is accelerated in a high vibration environment like that found in automotive and aircraft engines. The production of fines not only impairs the performances of the hydrogen generator, but may also lead to plugging of lines, etc., downstream of the generator. The use of monoliths represents a considerable improvement in this area. Unfortunately, monolithic catalysts have only recently been introduced, specifically in the automotive emissions area. A good monolithic catalyst for the higher temperature service in the hydrogen generator is currently not available commercially. The objective of this RTOP is to develop a suitable monolithic catalyst bed for use in the on-board hydrogen generator. A monolithic catalyst bed has some additional advantages: lower pressure drop, higher allowable space velocities, faster cold start, easier to use electric heater for startup. Catalyst manufacturers consider almost all their products proprietary and will not disclose their manufacturing procedures. It is the intent of this RTOP to document the preparation procedures of the catalysts that will be developed by working with catalyst laboratories that are agreeable to this policy. A secondary objective is therefore to develop a 'catalyst technology package' that will be generally available and that will document both the preparation procedures as well as the properties of the developed catalysts. Such a package should enable any commercial catalyst manufacturers to produce the unit.

**W77-70055** **505-06-11**
Langley Research Center, Langley Station, Va.
**COMPUTATIONAL AERODYNAMICS**
P. J. Bobbitt 804-827-2627
(505-06-14; 505-06-15)

The objective is to develop the capability to analytically predict complete aerodynamic characteristics of complex three-dimensional aircraft configurations, now obtainable only by extensive wind tunnel tests (constrained by Mach number and Reynolds number limitations, sting and wall interference effects) to a degree that preliminary design concepts can be evaluated, screened and, to a degree, optimized with reduced wind tunnel test time and cost. Analytical and numerical procedures will be developed for the prediction of flow fields, pressure distributions, aerodynamic characteristics, skin friction and heat transfer for inviscid, viscous and coupled inviscid-viscous flows with attached and separated boundary layers, detached lee side flows with vortex formation and other interactions. Both linear and nonlinear, exact and approximate flow equations will be applied as appropriate. Mathematical techniques required typically depend on the problem; however, finite-element, finite-difference relaxation, time-asymptotic, characteristics and integral methods are the most commonly used for solving nonlinear problems. Linear problems will generally be solved by the distribution of various types of singularities whose strengths are determined by the solution of a matrix equation. Several problems requiring large computer storage will be programmed for the STAR with particular emphasis on efficient explicit solution algorithms. Research on inviscid-flow methods will concentrate on subsonic and transonic flows while viscous techniques will also involve supersonic flows.

**W77-70056** **505-06-12**
Ames Research Center, Moffett Field, Calif.
**DEVELOPMENT OF AERODYNAMICS CODES FOR LARGE COMPUTERS**
D. R. Chapman 415-965-5065
(505-15-11; 505-15-31)

The objective is to develop efficient codes for solving fluid dynamics problems on the ILLIAC IV and advanced vector processing computers. The complete spectrum of aerodynamics, from low supersonic to hypersonic speeds will be studied for steady and unsteady, inviscid and viscous flow over two- and three-dimensional configurations. Specific objectives are categorized under (1) programming languages, (2) transonic flow, (3) supersonic flow, (4) viscous flow, (5) turbulence. The approach is to program in a language that is relatively simple but offers the most effective utilization of a particular computer. The numerical analysis will emphasize methods that are especially suitable for vector and parallel processing. Both simple flows with exact solutions and experimental data will be used to verify the computer simulations.

**W77-70057** **505-06-13**
Ames Research Center, Moffett Field, Calif.
**PHYSICAL MODELING AND VERIFICATION OF ADVANCED COMPUTER CODES**
D. R. Chapman 415-965-5065
(505-06-12)

The objective is to perform fundamental experiments specifically designed to verify two- and three-dimensional advanced computer codes and to provide the necessary modeling

of the physics of turbulent flows to be included in these codes. The Reynolds number domain will extend to the practical range of existing and future aircraft for the transonic and supersonic speed regimes. Flows to be studied will emphasize pressure gradients, separation, and shock interaction regions. Initial objectives are to perform experiments relevant to the development and verification of transonic computer codes currently being developed. A series of experimental test geometries will be thoroughly documented. The measurements will include both mean surface and flow-field quantities as well as the fluctuating, turbulent flow-field quantities. Each test geometry will be specifically designed to test a concurrently developed computer code and the various turbulence models employed in the code. Planned test geometries include both two and three-dimensional viscous flows with various degrees of complication including pressure gradient, separation and shock interaction regions.

**W77-70058** **505-06-14**
Langley Research Center, Langley Station, Va.
**THREE-DIMENSIONAL SEPARATED FLOWS**
R. E. Bower 804-827-3285

The objectives are to perform basic research advancing the knowlege and prediction of aerodynamic phenomena involving various three-dimensional separated flows at subsonic and supersonic speeds. Flows such as separation-induced vortex flows with reattachment on lifting surfaces and cross-flow separation on fuselages at high angles of attack are being studied. Theoretical and empirical methods are being developed to allow prediction of the static and dynamic aerodynamic characteristics and critical design loads of aircraft configurations to a degree that preliminary design concepts can be evaluated with reduced wind-tunnel test time and cost and the aerodynamic and structural trades can be more nearly optimized. Methods of optimizing and augmenting the separation induced vortex lift for improved maneuver lift will be studied as well as utilizing vortex flow over cambered leading edges for both cruise and maneuver. In-house experimental and analytical studies augmented by studies performed under contracts and grants will be utilized to accomplish the objectives. The development of theoretical methods for lifting surfaces will utilize finite element techniques and the edge suction analogy method. The body cross-flow research will involve extension of 'cross-flow' data to high Reynolds number and Mach number in the 1/3-meter transonic cryogenic tunnel and development of semi-empirical prediction methods for rotating bodies. Favorable component interference and powered augmentation methods will be used to improve the vortex-induced maneuver lift.

**W77-70059** **505-06-15**
Langley Research Center, Langley Station, Va.
**TURBULENT BOUNDARY LAYERS AND VISCOUS DRAG REDUCTION**
R. E. Bower 804-827-3285

The objective is to significantly improve our ability to predict the behavior of general turbulent shear flows including turbulent boundary layers and free mixing flows for aeronautical design purposes. Theoretical and experimental research on turbulent boundary layers, free mixing layers, and recirculating flows including effects of compressibility, pressure gradients, mass and heat transfer and three-dimensional flows on turbulence modeling. To provide the technology basis for more fuel efficient energy conserving aircraft through development and optimization of turbulent skin friction reduction concepts, thus conserving our nation's energy resources and enhancing our nation's competitiveness in the international aircraft market. A coordinated theoretical and experimental program in which theoretical turbulence models are postulated based on the physics of the situation, with inputs from carefully conducted experiments which measure (1) surface shear and heat transfer and (2) detailed structure of turbulent flows obtained by standard techniques and by means of hot wires, lasers and other advanced measurement techniques. Detailed data and turbulence models are used to develop and verify several large numerical codes including computational methods for three-dimensional boundary layers, three-dimensional fluid mixing, vortex and separated flows. Experimental and theoretical research will be conducted to examine promising turbulent viscous drag reduction concepts such as compliant walls and gaseous slot injection. Other new and innovative concepts, such as turbulence control, will be studied as they are identified.

**W77-70060** **505-06-15**
Ames Research Center, Moffett Field, Calif.
**TURBULENT BOUNDARY LAYERS**
Richard H. Petersen 415-965-6116
(505-06-11)

The objective is to conduct analytical and experimental investigations of turbulent boundary layer flows under conditions where present understanding of such flows is inadequate. These conditions include: (1) flows over highly curved surfaces providing severe adverse pressure gradients (with and without mass addition or removal), and (2) flows in the immediate region of, and downstream of, shock-wave boundary-layer interactions. The flow may be attached or separated in the foregoing cases. The results will be utilized to obtain empirical turbulence models for use in advanced computer programs for calculating complete flow fields including regions in which viscous separated flows play a predominate role. An example would be flow fields occurring on transonic airfoil sections with specifically tailored pressure gradients.

**W77-70061** **505-06-17**
Ames Research Center, Moffett Field, Calif.
**EFFECTS OF AIRCRAFT FLOW FIELDS ON A LASER BEAM**
Richard H. Petersen 415-965-6699

The object of the research is to predict electromagnetic wave distortion in the visible and infrared portions of the spectrum, resulting from propagation through an open port of an airplane turret. This program will consist of both theoretical and experimental research. Wind-tunnel tests simulating the various types of flow surrounding the turret will be conducted for the purpose of improving existing or new theory. The tests are also intended to provide a better understanding of the phenomena so that the distortion can be minimized. The tests will include a scale model an an actual flight system, and the results will be correlated with flight test data to be obtained by the Air Force Weapons Laboratory.

**W77-70062** **505-06-18**
Ames Research Center, Moffett Field, Calif.
**DEFINITION OF OPTIMIZED PROCESSOR FOR COMPUTATIONAL FLUID DYNAMICS**
D. R. Chapman 415-965-5065

The objective is to define a special purpose processing facility for solving the equations of fluid dynamics at speeds two to three orders of magnitude faster than possible now with general purpose computers. The proposed facility is to serve as an engineering tool for obtaining computer simulations in five to ten minutes for time-averaged viscous flow over wing-body configurations. This will permit: (1) substantial reduction of wind tunnel tests required in a preliminary aerodynamic design of new aerospace vehicles, (2) design information over the entire flight envelope at full-scale Reynolds numbers not obtainable in most wind tunnel tests, and (3) a new capability through computer optimization techniques to design aerodynamic shapes of greater efficiency than has been previously possible through conventional cut-and-try methods of wind tunnel testing. The definition studies funded by this RTOP can lead to the design and construction of a fully operational facility.

**W77-70063** **505-06-19**
Ames Research Center, Moffett Field, Calif.
**PREDICTION METHODS FOR THE AERODYNAMICS OF CRUISE FLIGHT**
G. T. Chapman 415-965-5859
(505-06-15; 505-06-43)

The primary objective is to develop prediction methods that utilize analytical, computational and experimental information in an integrated, optimum manner for the study of complex aerodynamic flow fields at subsonic through supersonic flight speeds. The procedures will apply to two and three-dimensional configurations and will include consideration of viscous effects, with and without separation. Finite difference, relaxation

techniques, and integral methods shall be used as appropriate as well as data obtained with advanced experimental techniques. In addition, techniques will be developed to predict the lift and drag for complete aircraft configurations. As these methods become available, optimization procedures will be developed to predict configurations with optimum aerodynamic performance.

**W77-70064** **505-06-21**
Ames Research Center, Moffett Field, Calif.
**UNSTEADY AERODYNAMICS**
Richard H. Petersen 415-965-6134
(505-02-21)

The broad objective of this RTOP is to study the unsteady aerodynamics of 2-dimensional airfoil sections in the transonic speed regime and to assess and improve methods of predicting motion dependent unsteady aerodynamics. The results of this research are applicable to aircraft as well as helicopter rotors. Specific objectives include the investigation of the Kutta condition extended to unsteady flows, the effect of viscosity on unsteady flows, dynamic stall, wind-tunnel wall effects in compressible flow, and the development of new experimental techniques for studying unsteady flow fields. Much of the theoretical work on these subjects will be performed on university grants. Complimentary experimental work will be performed in house in the Ames 25 x 35 cm Vacuum Wind Tunnel (VWT) and on the 2-dimensional oscillating apparatus in the Ames 11-Foot Transonic Wind Tunnel (TWT). The program described in this RTOP is part of a coordinated program of research at Ames Research Center, Langley Research Center, and the Air Force Flight Dynamics Laboratory to improve the understanding and prediction of transonic unsteady aerodynamics.

**W77-70065** **505-06-23**
Ames Research Center, Moffett Field, Calif.
**AIRFRAME AERODYNAMIC NOISE OF SHORT-HAUL AIRCRAFT**
C. T. Snyder 415-965-5567
(505-03-12)

The objectives of this RTOP are to determine the design principles and provide data required for the reduction of airframe noise of short-haul aircraft. At the present time, the noise level and spectra from the major sources of airframe noise are being identified by a series of comprehensive measurements in the 40- by 80-Foot Wind Tunnel. Special emphasis is being placed on noise emitted by slats and flaps, since these high-lift devices are paramount for short-field performance. Other noise sources investigated include vortex systems and wakes, cavities, and landing gears. Special diagnostic techniques are under development for discriminating the desired noise signal from the extraneous noise generated in the wind tunnel environment. In addition, the source of this extraneous noise is being located, and attempts will be made to lower or eliminate such noises. A parallel theoretical effort for the prediction of noise generated by flaps, slats, landing gear, and cavities is also underway. The theory will require measured fluctuating pressures and velocity gradients as input data. A better understanding of the fundamental mechanisms will be used to design incisive configuration modifications which will reduce aircraft noise to acceptable levels. noise reduction techniques will be verified in a series of wind tunnel tests on models of existing aircraft and representations of future aircraft.

**W77-70066** **505-06-23**
Langley Research Center, Langley Station, Va.
**AIRFRAME AERODYNAMIC NOISE**
R. E. Bower 804-827-3285

Techniques are being developed for using small scale models of complete aircraft for airframe noise research. These techniques include the use of radio-controlled, free flight models and aerodynamic and acoustic testing in quiet flow facilities. Aerodynamic similarity and integrity of these models must be assured in the course of this research. By testing models in various configurations, those portions of the airframe principally responsible for noise generation can be identified. Models will also be used to measure details of airframe noise directivity, to develop scaling laws for comparison of model and full-scale data and to test noise reduction and control methods. A considerable effort is also directed toward understanding the production and characteristics of noise from individual aircraft components. Cavities representing open wheel wells and flap trailing edges are receiving special emphasis. Experimental studies to obtain a systematic data base on cavity noise and the development of empirical and theoretical schemes for cavity noise prediction are continuing. A study to investigate the interaction of wing, slat, gear, and flap flow fields will begin in order to identify and understand combinations of components which may be significant noise sources. The relationship between aircraft drag and airframe noise will be investigated experimentally and analytically using models of simple body shapes.

**W77-70067** **505-06-31**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**AIRFOIL AND CONFIGURATION AERODYNAMICS**
E. J. Saltzman 805-984-8606

The objective is to improve ability to predict the aerodynamic efficiency of vehicles which move through the atmosphere. Also, to define how the efficiency of airfoils or complete vehicles is influenced by geometry, Reynolds number, surface roughness and texture, and free-stream and local flow conditions. In addition, experimental research on turbulent boundary-layer phenomena will be conducted. The latter will include exploratory model studies of the use of wing sweep for boundary-layer removal on a swept back-swept forward (diamond) wing combination to improve maneuverability at low and transonic speeds. These objectives will be approached through analytical and conceptual studies as well as through the experimental approach. Overall and incremental drag of powered and coasting vehicles will be defined by the accelerometer and/or dynamic analysis methods augmented by the stabilized glide and rate of sink methods. Airfoil performance will be defined by conventional pressure distribution techniques, boundary-layer rakes and trailing wake probes augmented by flow visualization where required. Pressure distribution techniques will also be used in assessing bottail and base drag and in studying means of reducing these components of drag.

**W77-70068** **505-06-32**
Langley Research Center, Langley Station, Va.
**AIRFOIL DESIGN AND ANALYSIS SERVICES FOR GENERAL AVIATION**
P. K. Pierpont 804-827-2210
(505-06-31)

The objectives are to develop capabilities outside of government organizations to use advanced analytical methods and computer programs to design and develop new airfoils, flaps, and controls for specific applications. In the face of strong international competition, such new expertise will provide needed additional direct technical support for the U.S. General Aviation industry. Specific applications will include light to medium weight single and twin engine private, sports, agricultural, and business aircraft - both propeller and jet types. The work will include: (1) dedication of contractors' existing computational facilities and aerodynamic analysis competence, (2) implementation of government supplied airfoil analysis and design programs and techniques, including 'tuning' and 'optimization' procedures where applicable, (3) demonstration of operational analysis and design capabilities, and (4) conduct of analysis and design services to both industry and government. The expertise to be developed is intended to expedite introduction of the advancements in airfoil, controls, and high lift technology into U. S. manufactured aircraft, and to permit NASA research scientists to focus on further advancements in analysis methods and numerical design techniques.

**W77-70069** **505-06-33**
Langley Research Center, Langley Station, Va.
**AIRFOIL AERODYNAMICS**
P. K. Pierpont 804-827-2210
(505-06-11; 505-10-11; 505-10-21)

The objective is to provide improved airfoils and multi-element high lift airfoils in four major sub-program areas: (1) advanced fixed-wing subsonic aircraft, (2) transonic executive and commercial transports and military aircraft, (3) advanced military

and civil helicopters, and (4) special applications such as remote piloted vehicles (RPV's) and outsized cargo aircraft. Improvements are sought in the areas of basic aerodynamic performance, high lift and controls performance, and stall behavior. The work will be an intermix of both experiment and applied theory and will provide: (1) measurements of aerodynamic characteristics for selected configurations, (2) upgraded predictive aerodynamic analysis, (3) generation of airfoil design methodology for both subcritical and supercritical aerodynamic regimes, and (4) stimulation of new and unique design concepts, theoretical methods, and experiment techniques. Examples include new supercritical airfoils, General Aviation airfoils, leading trailing edge high lift devices, and new rotorcraft blade sections. In addition, the work includes improvements in existing research facilities and techniques together with development of new and unique capabilities. These new capabilities are specifically directed toward achievement of high quality data at intermediate and very high Reynolds numbers, such as are obtainable through cryo-technology, at high angles of attack at transonic speeds, and at very high coefficients using multi-element airfoils at subsonic speeds.

**W77-70070** **505-06-34**
Ames Research Center, Moffett Field, Calif.
**AERODYNAMICS OF MULTI-ELEMENT AIRFOILS AND WINGS**
C. T. Snyder 415-965-5567

The objective is to develop theoretical methods to predict the viscous/potential flow about multi-element high-lift airfoils and multi-element finite wings. Experimental data required for development and confirmation of the theoretical studies will also be obtained. As these theoretical tools become available, configuration optimization of multi-element airfoils and wings will be developed to predict the configuration of high-lift devices such that maximum aerodynamic performance is obtained. The optimization studies will also be supported by experimental investigations.

**W77-70071** **505-06-41**
Langley Research Center, Langley Station, Va.
**BOUNDARY LAYER STABILITY AND TRANSITION**
R. E. Bower 804-827-3285

The objectives are to: (1) identify and control sources of stream disturbances in supersonic/hypersonic wind tunnels, (2) identify and control dominant causes of transition in nozzle wall boundary layers, (3) develop and test noise shield concepts to reduce and control test section noise levels, (4) develop methods to predict effects of various disturbances on transition and on fully turbulent boundary layers and shear layers, and (5) design and construct a 1/2-Meter 'Quiet Tunnel.' The approach is to test and perfect settling chamber components, laminar flow nozzles, and sound shields in a Mach 5, 5-inch exit diameter, Pilot Quiet Tunnel. Hot-wire and high frequency response pressure transducers (or microphones) are used to determine disturbance sources, amplitudes, and scales. All phases of the work are being conducted under close consultation with Reshotko, Klebanoff, and other members of the NASA Transition Study Group. The 1/2-Meter Quiet Tunnel will be constructed in two phases as follows: Phase I is now underway and consists of modifying and mounting an existing heater case as a settling chamber plus the development and testing of optimum components such as turbulence screens, baffles, and acoustic silencers which have to be tailored to the specific installation. Phase II will be funded with C of F money and consists of the design and construction of a laminar flow nozzle and the design and fabrication of the test section, noise shield, and vacuum system.

**W77-70072** **505-06-42**
Ames Research Center, Moffett Field, Calif.
**ADVANCED WIND TUNNEL CONCEPTS**
Richard H. Petersen 415-965-5850

The general objective of this research is to develop by FY-79, improved wind tunnel test techniques in order to ensure reliable correspondence between viscosity-dependent data obtained from scale-model tests and that from full-scale flight tests. Tunnel wall constraints, flow quality and means for simulating higher Reynolds number flow will be investigated analytically and experimentally.

**W77-70073** **505-06-42**
Langley Research Center, Langley Station, Va.
**ADVANCED WIND TUNNEL CONCEPTS**
R. E. Bower 804-827-3285

The technical objective is to provide the technology for improved wind-tunnel test capability for experimental prediction of performance and flight characteristics of conceptual or new aircraft designs and basic research in the critical high subsonic and transonic speed regimes. In-house, contract and grant research, both analytical and experimental, will be used with efforts concentrated in the following areas: (1) basic thermodynamic and aerodynamic research required to established minimum operating temperature limits for various types of cryogenic wind tunnel testing, (2) research and development directed towards application of the superconducting magnetic balance and suspension system to the 1/3-meter transonic cryogenic wind tunnel to provide support interference free test capability at resonable levels of Reynolds number, (3) research on transonic tunnel walls designed to minimize interference and the development of improved wall interference correction methods, (4) research and development on model design, instrumentation, test techniques and tunnel circuit efficiency required for accurate and efficient testing at high Reynolds numbers, and (5) support of the 1/3-meter transonic cryogenic tunnel with regard to nitrogen supply specialized equipment, and stock items to carry out research in the above areas.

**W77-70074** **505-06-43**
Ames Research Center, Moffett Field, Calif.
**FLOW MEASUREMENT TECHNIQUES**
Richard H. Petersen 415-965-5655
(505-06-15; 505-06-31; 505-06-95)

Laser velocimeter systems are being developed to obtain mean velocities, turbulence intensities, and Reynold stress components, in subsonic, transonic, and supersonic flows with and without separation. The systems include a 4-watt system used in the Ames 8- by 8-inch Supersonic Wind Tunnel and a 15-watt system for applications in the Ames 2- by 2-Foot and 6- by 6-Foot facilities. Basic fluid mechanics studies will continue, investigating such flow as shock boundary-layer interactions with separation, corner flows, and compression corners. The technique will also be applied to the investigation of transonic flow about two-dimensional airfoil sections and the vortex flow patterns behind wing-body configurations at high angles of attack. Further development of the overall system will include: the use of autocorrelation techniques to process signals with low signal-to-noise ratios, improvements in spatial resolution, and the use and generation of particles appropriate for seeding wind tunnel flows. The work under this RTOP will be coordinated with the turbulent boundary-layer effort of RTOP 505-06-15, the prediction of aerodynamics of cruise flight effort of RTOP 505-06-11, and the high angle of attack aerodynamics effort of RTOP 505-06-95.

**W77-70075** **505-06-43**
Langley Research Center, Langley Station, Va.
**FLOW MEASUREMENT TECHNIQUES**
R. E. Bower 804-827-3483
(505-06-43)

This effort will develop instrumentation technology to improve measurement techniques to satisfy present and future aeronautical testing requirements. The work is predominately an in-house effort with emphasis placed on research where successful results will provide measurement technology broadly applicable to aeronautical programs. Technology developed under this RTOP will be coordinated with more focused instrument development in other programs. Research to be pursued includes development of gas velocity measurement techniques, improvements in thermal mapping measurements, aerodynamic load measurements, model attitude, and skin friction sensors. These research tasks will be continually alined with present and projected aeronautical program measurement requirements.

**W77-70076** **505-06-91**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**HANDLING QUALITIES - CRITERIA FOR HIGHLY AUGMENTED VEHICLES**
D. T. Berry 805-258-3311

The overall objective of this effort is to advance fundamental knowledge of the interactions between the pilot and the aircraft/flight control systems, and to exploit this knowledge to develop methods for optimizing system performance while minimizing cost and complexity. Analytical studies, computer simulations and flight research are being performed both in-house and under research contracts and grants to meet this objective. The range of command responses of augmented aerospace vehicles that optimizes the pilot-vehicle performance for specific missions or a specific task within a mission will be investigated. The main emphasis will be to investigate criteria for desired command responses that are meaningful to the systems designer and not needlessly restrictive as to the system concept employed.

**W77-70077** **505-06-93**
Langley Research Center, Langley Station, Va.
**ADVANCED FLIGHT DYNAMICS RESEARCH**
R. E. Bower 804-837-3285
(505-07-21; 505-10-13)

The objectives are: (1) to provide advanced methods for extracting accurate aerodynamic parameters from flight data, for use in flight dynamics analyses, simulation of aircraft, control system design, and correlation with wind-tunnel and analytical results. Emphasis will be on the nonlinear, high-angle-of-attack region of importance to spinstall situations, (2) extend decoupled-control concepts to use in general aviation This should simplify piloting techniques and so improve safety of flight, (3) investigate handling qualities requirements for advanced aircraft such as flying wings, very large transports, and active-controls aircraft, (4) study nonlinear aerodynamic effects on roll-coupling instability of high performance aircraft. The approach will be to incorporate several improvements in current parameter-extraction program, including apriori weighting, rank reduction, modeling noise, and so on, (5) incorporate some nonlinear coefficients into program for high-angle-of-attack regions, (6) develop techniques for application to helicopters, (7) conduct analytical, simulation, and flight tests of decoupled-control systems to specific flight situations and to general aviation, (8) investigate several methods of implementing decoupled controls, (9) examine flying qualities of advanced large transports, through analyses and simulation, (10) compare with current requirements for applicability or required modifications, (11) modify existing program for analysis of roll coupling, to include nonlinear aerodynamic effects, and (12) develop analytic criteria to avoid sudden departures in maneuvering flight.

**W77-70078** **505-06-95**
Langley Research Center, Langley Station, Va.
**VEHICLE DYNAMICS - STALL/SPIN/HIGH-ALPHA CHARACTERISTICS**
R. E. Bower 804-827-3285
(505-11-41)

The broad objective is to improve the stall/spin characteristics of aircraft, and to determine the effects of these characteristics in terms of piloting the aircraft. Specific objectives are: (1) to investigate the fundamental nature of stall/spin including the development of test techniques and methods for theoretical analysis, (2) to develop and evaluate the effectiveness of automatic spin prevention concepts, (3) to determine static and dynamic aerodynamic characteristics of current and advanced configurations at high angles of attack, and (4) to determine geometric characteristics which result in inherent spin resistance. The methods of approach include static and dynamic wind-tunnel force tests, theoretical analysis, piloted simulator tests, and dynamic model flight tests.

**W77-70079** **505-06-97**
Ames Research Center, Moffett Field, Calif.
**HIGH ANGLE OF ATTACK AERODYNAMICS**
Richard H. Petersen 415-965-6396
(505-06-43)

The objective is to provide a basic understanding of high angle-of-attack aerodynamic characteristics of highly maneuverable aircraft through the development of improved theoretical methods supported by static and dynamic wind tunnel tests. Ultimately, through the application of improved methods and test results, new criteria can be established for designing vehicles capable of performing controlled maneuvers over an expanded angle-of-attack envelope. Theoretical methods for calculating static aerodynamic coefficients are being developed in-house and on contract. Experiments in several wind tunnels are being performed to study basic aerodynamic flow phenomena, especially at high angles of attack. Investigations are in progress to evaluate various experimental methods for determining dynamic characteristics of aircraft and experimental capabilities are being upgraded for testing at high angles of attack and high Reynolds numbers, both for static and dynamic characteristics. Dynamic apparatus are being constructed to evaluate aerodynamic coefficients which are pertinent to all phases of high-maneuver flight from controlled motions to fully developed spins.

**W77-70080** **505-07-10**
Ames Research Center, Moffett Field, Calif.
**APPLICATION OF GUIDANCE AND NAVIGATION THEORY TO OPERATIONS OF FUTURE SHORT HAUL AIRCRAFT**
C. T. Snyder 415-965-5450
(505-07-11; 513-53-03; 513-54-01; 513-50-06)

The objective of this research is to extend and apply modern guidance and navigation theory to optimize future short-haul aircraft operation in a high density air traffic environment. Three major efforts support this objective: (1) Methodology and on-board computer techniques for flying minimum fuel and noise flight paths subject to air traffic control, passenger comfort and safety constraints are to be developed. These techniques will be applied to in-service short-haul and future STOL and VTOL aircraft. Resulting system designs in studies and piloted simulations and, where warranted, in flight tests on selected STOL, VTOL and Rotorcraft Research Vehicles will be evaluated. (2) The impact of the current and future air traffic control system on shorthaul aircraft guidance and navigation system designs will be determined. These investigations are conducted jointly with the FAA. Piloted simulators, together with the Ames Terminal Area Simulation Facility, are used to conduct these studies. (3) More efficient analysis and synthesis procedures for advanced aircraft guidance and navigation systems designs will be developed through university grants.

**W77-70081** **505-07-11**
Ames Research Center, Moffett Field, Calif.
**APPLICATION OF ADVANCED CONTROL THEORY TO THE AUTOMATIC AND MANUAL CONTROL OF FUTURE STOL, VTOL, AND ROTORCRAFT**
C. T. Snyder 514-965-5567
(513-53-03; 513-54-01)

Advanced linear and nonlinear modern control theory will be extended and applied to the automatic and manual control of STOL, VTOL and rotorcraft. The major effort is the design of a Full Flight Envelope Autopilot (FFEAP) which uses a digital computer and nonlinear aircraft force and moment equations to calculate open loop and corrective closed loop control sequences which smoothly follow and regulate general ATC trajectory commands. The system performance will be verified by an experimental flight program using the STOLAND system and augmentor wing jet STOL aircraft. The FFEAP design technique will also be applied to the tilt rotor aircraft. Advanced control strategies and model development required to augment and extend automatic and manual control of STOL and VTOL aircraft will be obtained through university grants and independent projects conducted by NRC Research Associates.

**W77-70082** **505-07-12**
Langley Research Center, Langley Station, Va.
**JOINT UNIVERSITY PROGRAM ON AIR TRANSPORTATION SYSTEMS**
J. E. Stitt 804-827-3745
(512-52-02; 513-50-51; 513-52-01)

The primary objective of this effort is to foster development

of a university research capability across the disciplines that involve the avionics and flight control systems of aircraft and their interaction with the air traffic and airport operating environments. A secondary objective is to encourage university interest in inter-disciplinary education that will provide engineers and scientists capable of attacking the system's problems involved in these areas of air transportation. Efforts to further improve communications and interactions between the schools, and to foster initiation of complementary projects will include joint quarterly meetings of the personnel involved at each school, the production and exchange of video recordings of technical lecture, the exchange of flight and simulation data, and the exchange of students between schools for portions of their academic work. NASA, FAA, DOD, and industrial and aircraft-user personnel will participate in the quarterly reviews for program guidance and coordination.

**W77-70083** **505-07-13**
Langley Research Center, Langley Station, Va.
**DIGITAL AND ACTIVE CONTROL TECHNOLOGY**
J. E. Stitt 804-827-3745
(512-51-02)

The objective of this research is to provide a technological base for improved analysis and synthesis procedures for future aircraft designed to maximize benefits achieved through the application of modern guidance and control theory with emphasis on digital active control technology. The goals of this research are to provide structural, performance, and handling qualities factors for a wide class of aircraft designs and missions. Improvements derived through this program will be used in technology demonstration programs such as ACEE/EET. University grants, industry contracts, and inhouse research will be coordinated to provide a balanced research and technology base program. Integrated analysis and synthesis procedures will be developed to properly blend elements of sensors, actuators, control surfaces, unsteady aerodynamics and structural dynamics so as to realize the benefits available from active control technology. New theoretical models to more effectively describe the unsteady aerodynamic and control phenomena and new control concepts brought about by the introduction of digital computers and sampled data system technology into aircraft flight control system design will be developed. Alternatively, new tools will be developed to analytically anticipate and provide margins of safety for design factors such as unmodeled dynamics and uncertain parameters. Assessments of the benefits in structural integrity, performance, economics, etc., will be made.

**W77-70084** **505-07-14**
Langley Research Center, Langley Station, Va.
**ADVANCED SENSING TECHNIQUES FOR AERONAUTICS AND STRUCTURES RESEARCH**
J. E. Stitt 804-827-3745

The broad objective is to develop the advanced sensing technology needed to support the NASA research program in aeronautics. Special attention will be given to key measurement problems which impede LRC aeronautics and aircraft structures research and to the support of a concerted effort to achieve their solution. Work to be covered under this task will include the investigation of new sensor and measurement concepts, R&D of emerging sensing technology and proof-of-concept demonstration of advanced measurement capability. Non-intrusive gas flow field measurement techniques for wind tunnel model flow fields, combustion flows and turbulence will be investigated and developed with special emphasis placed on laser velocimetry and Raman spectroscopy. Acoustics and boundary layer probe measurements and sensor performance will be improved through advances in solid state sensor technology. New and improved non-destructive evaluation techniques will be explored to detect flaws and measure internal stress levels in laboratory structural material specimens, and monitor wear particles in aircraft lubricating oils. Laboratory analytical measurement methods will be developed to permit research on composite material chemistry, structural changes and environmental effects (especially humidity) at the atomic level. New concepts will also be explored in other measurement problem areas to extend present state-of-the-art, e.g. wind tunnel model angle of attack, model wing deformation, and skin drag force.

**W77-70085** **505-07-22**
Langley Research Center, Langley Station, Va.
**AVIONICS ANTENNA TECHNOLOGY (GENERAL AVIATION)**
W. F. Croswell 804-827-3631

The objective of this RTOP is to develop low cost antenna technology for avionics systems that will be added to the existing aircraft. This includes the development of low profile antennas that can be added on with a minimum of structural penetration, and the determination of optimum locations of antennas using computer aided design techniques. The approach to be used is to extend previous work on printed microstrip and other low profile antennas to produce practical antenna elements and arrays with the polarization patterns and gain required; extend present computer programs and analysis to allow treatment of GA aircraft; and to conduct computerized siting studies along with extensive measurements using scale model aircraft. The results expected include prototype antenna hardware and drawings, a documented siting and antenna type study for programs such as MLS and GPS, flight testing of antennas on selected aircraft.

**W77-70086** **505-07-24**
Wallops Station, Wallops Island, Va.
**INNOVATIVE AVIONICS/PILOT ADVISORY SYSTEM**
L. C. Parker 804-824-3411

The objective is to determine the feasibility of a low-cost aided radar system for automatic mid-air collision warning on a non-cooperative basis to all aircraft equipped with only standard NAV-COM systems in an uncontrolled air traffic terminal area. Studies will be performed to define the uncontrolled air traffic parameters, mid-air collision dynamics, systems approaches for detecting collision situations in this environment and for providing warnings to pilots involved. The feasibility of a system to provide pilot warnings and to prevent mid-air collisions in the uncontrolled terminal airspace will be evaluated analytically and demonstrated using existing and experimental breadboard systems.

**W77-70087** **505-07-31**
Langley Research Center, Langley Station, Va.
**HIGHLY RELIABLE CIVIL AIRCRAFT COMPUTER TECHNOLOGY**
J. E. Stitt 804-827-3745
(513-52-01; 505-07-41)

The objective is to develop reliability assessment modeling techniques for use in evaluating fault-tolerant multi-microprocessor computer systems. Existing reliability models will be improved by including software error/fault effects and transient error effects. Feasibility will be determined for using a diagnostic emulator in the investigation of software fault impact on computer systems reliability. A concept for the design and modeling of fault-tolerant software will be investigated.

**W77-70088** **505-07-41**
Langley Research Center, Langley Station, Va.
**AUTOMATED AVIONICS**
J. E. Stitt 804-827-3745
(513-53-04; 513-54-02; 505-20-23)

This effort will derive and validate the advanced avionics technology required for reliable IMC (Instrument Meteorological Conditions) operations with emphasis on the terminal area. The current focus for this work is the commercial operation of helicopter systems in the 1980's. Technology developed under this RTOP along with coordinated efforts in aeronautics (505-10-23) and operating systems (513-54-02) has the goal of demonstrating the operational capability of the helicopter as a viable intra/inter urban transportation system. The navigation, guidance, and control requirements for enroute, terminal area, and approach and landing of helicopters will be determined with emphasis on automatic operations. New technology will be used to develop low cost and reliable radio-inertial navigation systems, displays, sensors, and to evaluate landing guidance systems. Designs of functionally integrated systems will be implemented in brassboard hardware and flight tests will be conducted to

evaluate and demonstrate systems performance. Guidance, navigation, and control requirements, and concepts will be investigated by extending previous analytical studies, simulation, and flight experiments to include automatic flight and landing operations.

**W77-70089** **505-08-10**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**KNOWLEDGE OF ATMOSPHERIC PROCESSES**
L. J. Ehernberger 805-258-3311
(516-51-02)

The objective of this work is the definition of the atmospheric conditions in which turbulence, temperature transients, potential pressure altimetry problems and excessive wind shears occur. The major emphasis is the atmospheric environment of supersonic aircraft. Development and acquisition of sensors needed to measure these phenomena are also included. Results of this work will be applicable to aircraft systems design, and flight test activities as well as to flight operations routing and scheduling. Observations of these phenomena are obtained from instrumented aircraft test flights. The associated meteorological conditions are analyzed and studied both in-house and on contract.

**W77-70090** **505-08-10**
Marshall Space Flight Center, Huntsville, Ala.
**KNOWLEDGE OF ATMOSPHERIC PROCESSES**
D. W. Camp 205-872-2087

The objectives are (1) the definition, modelling, and simulation of, steady state wind and turbulence environments for aircraft accident investigation and the identification of aircraft operating hazards, (2) the modification of airports, and (3) the development of techniques and procedures whereby the knowledge of the natural environment can be better utilized for the safe operation of aeronautical systems. The approach is to continue (1) the development of models of atmosphere boundary layer flow properties, (2) the development of probabilistic models of turbulence and the conditions which lead to turbulence, and (3) performing analytical and laboratory tasks relative to the life cycle of fog. To accomplish these objectives, the following tasks will be performed: (1) Task 01 - induced wind environments, (2) Task 02 - natural environment reconstruction for aircraft and operating hazard investigation, (3) Task 03 - free atmosphere perturbations, turbulence, and thunderstorm, and (4) Task 04 - fog modification. These activities shall be supported by a National Research Council (NRC) fellow. The resources for the NRC fellow will be obtained from this RTOP funding.

**W77-70091** **505-08-10**
Wallops Station, Wallops Island, Va.
**KNOWLEDGE OF ATMOSPHERIC PROCESSES**
R. E. Carr 804-824-3411

The objectives of this research program are: (1) to develop a meteorological data-measuring and data-acquisition system capable of measuring mean wind, mean temperature and the fluctuating wind components up to a frequency of 100 Hz, (2) to analyze the recorded data from measurements made at 50-foot intervals along the 250-foot meteorological tower at Wallops Island, and (3) to study the effect of varying atmospheric conditions and varying surface roughness conditions on the low-level atmospheric turbulence. The results of the analysis of these data will be compared with existing empirical statistical theories but may also be the basis for new theories. Other objectives are (4) to determine the statistical quantities describing the surface layer turbulence at Wallops Island, so that the general behavior of the flow in this layer as described in terms of these statistical quantities is predictable to a fair degree of accuracy, after some mean wind and mean temperature measurements are made at a few reference levels, and (5) to use the developed system in the research programs carried out at NASA Wallops Flight Center research airport. The approach is to design and to test an advanced state-of-the-art meteorological data acquisition system for recording of wind and temperature measurements in the atmospheric boundary layer. The design of this system should be flexible so that it can be easily adapted to make measurements at different locations. Another approach is to establish criteria for processing and analyzing of the data, and to develop proper calibration techniques for the instrumentation.

**W77-70092** **505-08-20**
Langley Research Center, Langley Station, Va.
**GENERAL AVIATION AIRCRAFT OPERATING EXPERIENCES**
R. E. Bower 804-827-3285

Statistical data on the operational experiences of general aviation airplanes are being collected and analyzed. Data are obtained by NASA VG and VGH flight recorders from airplanes involved in representative operations of general aviation aircraft usage. Data collected provide information on the ground and flight loads, on the airspeed and altitude operating practices, and on the aircraft's operating environment. The information obtained provides: (1) a continuous basis for comparing actual airplane loadings with design loadings, and, thereby, a check on the adequacy of design criteria; (2) a means of detecting unanticipated operational practices; and (3) provides a bank of data useful in the design and development of airworthiness requirements for new types of airplanes.

**W77-70093** **505-08-21**
Ames Research Center, Moffett Field, Calif.
**AVIATION SAFETY RESEARCH AND TECHNOLOGY - FIRE TECHNOLOGY**
D. R. Chapman 415-965-5065
(505-01-31; 510-56-01)

The objective is to explore fire-hardened concepts for aircraft interior materials systems such as lavatories, galleys, cargo compartments and aircraft interior passenger compartments, to reduce the threat to civil transport aircraft from (a) the inflight fire (b) the ramp fire and (c) the post-crash fire, to develop the technology base for fire safe aircraft systems utilizing the outputs of the R and T programs on fire-resistant materials and fire control systems, and to develop the chemistry base for advanced fire-extinguishants and less flammable hydraulic fluids. Laboratory tests will be conducted to assess the flammability, smoke and other properties of state-of-the-art and advanced composites which have a potential for increasing the fire-hardening of aircraft interiors. In regard to post-crash fires, fire-resistant structural panels and windows will be developed for evaluation. Solid fire extinguishants will be evaluated for use on engine nacelle fires for commercial and military aircraft. Hydraulic fuel chemistry being conducted for military programs will be examined for possible application to civil aircraft systems. Full advantage will also be taken from military programs concerned with fire-hardening of aircraft. Test methodology and criteria will be developed for assessing fore containment and other flammability parameters of aircraft interior materials.

**W77-70094** **505-08-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**AVIATION SAFETY R AND T - FIRE TECHNOLOGY**
R. R. McDonald 213-354-6186

The objective of this RTOP is to reduce the fire hazard associated with aircraft systems. This objective will be accomplished by research in two areas: (1) by modifications of the fuel, and (2) development of analytical methods for predicting thermochemical behavior of the polymers in a fire environment. Fuel Anti-Misting - Fuel additives will be developed which will markedly reduce the mist formed when a fuel tank or line is ruptured, with a consequent reduction in the fireball which can form on ignition. The effectiveness of these anti-misting agents appears to be related to the development of a high tensile viscosity, but also the effect is sensitive to high shear rates and temperature. A systematic study of such rheological behavior will be conducted to facilitate tailoring the additive and its concentration to varied use conditions. Thermochemical Modelling - Thermodynamic calculations and modelling will be accomplished to investigate the parameters that determine the potential for burning rate and smoke production with emphasis on polymer thermal stability and identification of polymer degradation products. Condensed phase thermochemical phenomena will receive attention in the light of previous experimental and theoretical work on the burning of solid propellants.

**W77-70095** **505-08-22**
Lewis Research Center, Cleveland, Ohio.
**AIRCRAFT OPERATIONS AND SAFETY R&T**
Donald A. Petrash 216-433-4000

The objective is to provide a broad base of safety-oriented technology for identifying, defining and dealing with the hazards associated with aeronautical systems; nd establish criteria for systems design and operating techniques leading to reduction in accidents, loss of life and injuries, and loss of equipment. The emphasis is on safety related to propulsion systems. The approach is to define, recommend, support and perform research activities that provide solutions to problems impacting on aeronautical safety; cooperate with other Lewis Divisions to exploit unique facilities and engineering talents necessary for addressing these safety problems; and coordinate research results with the FAA, NTSB, DOD, other interested government agencies, and the aeronautics industry. Specific areas of current research activities include: rotor burst protection, hi-energy brakes, and aircraft fire technology including fuel system hazards, lubricating sump fires, fire detection, and fire extinguishment.

**W77-70096** **505-08-22**
Langley Research Center, Langley Station, Va.
**HAZARD AVOIDANCE AND ELIMINATION**
R. E. Bower 804-827-3285

The objective is to provide basic technology for the improvement of the level of safety in aircraft operations with regard to natural atmospheric phenomena. Experimental flight research, analytical studies, and the collection of operational data in the area of natural atmospheric phenomena, (wind shears, lightning, low visibility) will be undertaken.

**W77-70097** **505-08-22**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**HAZARD AVOIDANCE FOR AIRCRAFT IN FLIGHT**
R. R. McDonald 213-354-6186

The overall objective of this effort is directed toward improving aircraft safety. During this period a practical approach to marking trailing vortices generated by large aircraft will be investigated, with emphasis placed on injection of a nonpolluting aerosol into the vortex to identify its location. The preprototype model, which has been designed and fabricated, will be evaluated to determine its ability to produce aerosol particulates in the 1u range. This size was determined theoretically to maximize light refraction. After necessary changes to obtain the proper size distribution, this system will be installed on an available aircraft to demonstrate feasibility. The flight testing phase will utilize NASA-DFRC facilities.

**W77-70098** **505-08-22**
Ames Research Center, Moffett Field, Calif.
**HAZARD AVOIDANCE - WAKE VORTICES AND WIND SHEAR**
C. T. Snyder 514-965-5567
(514-52-01)

The hazard in the terminal area from two forms of atmospheric disturbances, wake vortices and wind shear, will be studied. Research is needed to define the impact of new short-haul aircraft and the effect of new operational procedures on the separation required for following aircraft for wake hazard avoidance in the terminal area. This research will be accomplished through flight research using the Ames Learjet as a probe aircraft. Research on the wind shear problem will be conducted on the flight simulator for advanced aircraft. The basic factors that influence the hazard in the terminal area from shears and drafts will be identified, and means developed to reduce this hazard. Results are expected that will identify important aircraft performance and pilot perception factors, develop cockpit procedures and training, and produce flight path display concepts for further evaluation.

**W77-70099** **505-08-22**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**AVIATION SAFETY - FLIGHT TESTS OF WAKE VORTEX MARKING SYSTEMS**
M. R. Barber 805-984-8275
(505-08-20; 514-52-01)

This RTOP covers DFRC activities related to flight-test evaluations of environmentally acceptable vortex marking systems, specifically the J.P.L. (Tetra Ethylene Glycol) system will be flight tested in FY-77. An attempt was made to flight test the system on the space shuttle carrier aircraft B-747 in FY 1976. This attempt was unsuccessful; and, therefore, the RTOP is continued to provide flight testing when the marking system is ready.

**W77-70100** **505-08-22**
Marshall Space Flight Center, Huntsville, Ala.
**AVIATION SAFETY RESEARCH AND TECHNOLOGY/ HAZARD AVOIDANCE AND ELIMINATION**
E. A. Weaver 205-872-1597

The objective is to develop electro-optic remote atmospheric flow sensors using the laser Doppler technique. These sensors will be used to measure both natural and induced atmospheric flow phenomena concentrating on those that are hazardous to aircraft operations both in the terminal area and those that could be encountered along an airlane. The approach is to perform system feasibility studies, theoretical analyses, and design studies required to advance the system technology, and to perform breadboard hardware development and tests on existing hardware to determine feasibility, operational requirements, constraints, capabilities, and hardware specifications for specific sensor applications. Four major tasks will be performed: Task 1: pulsed CO2 Laser Doppler Turbulence Detection System; application studies, modifications, tests, and software, Task 2: CW Laser Doppler System; application studies, modifications, tests, and software, Task 3: Laser Doppler Technology; feasibility studies, supporting system R and T atmospheric effect, feasibility, atmospheric effect and operational technique studies, and Task 4: Wind Shear System Study; design study for a Pulsed Laser Doppler System at an airport to measure wind shear.

**W77-70101** **505-08-23**
Ames Research Center, Moffett Field, Calif.
**HAZARD AVOIDANCE - DATA PROCESSING AND FLIGHT SIMULATION FROM AIRCRAFT ACCIDENT RECORDINGS**
C. T. Snyder 415-965-5429

This is a cooperative program with the National Transportation Safety Board, Bureau of Aviation Safety (NTSB-BAS). The general objectives are to (1) develop improved data processing techniques for analyzing aircraft accident recordings, and (2) develop the capabilities at NASA-Ames to respond expeditiously when flight simulator analysis of an aircraft accident is deemed appropriate. Task 1 involves the investigation and evaluation of advanced data analysis methods (e.g., smoothing and parameter identification) for the processing of data from either the foil or digital flight recorders along with ATC radar records. These advanced methods will be used to obtain, from a limited set of accident data, a comprehensive scenario of the aircraft's position, velocities, orientation, configuration changes, etc., and other derived information which may not have been directly recorded. Task 2 involves the development of the capability to expeditiously simulate, using a piloted flight simulator, a given aircraft accident and the use of this flight simulator to aid NTSB in accident investigations. The data from Task 1 would be used to help ensure that the flight simulations resulted in a faithful reproduction of the given aircraft accident.

**W77-70102** **505-08-25**
Langley Research Center, Langley Station, Va.
**WIDE-BODIED JET TRANSPORT OPERATING EXPERIENCES**
R. E. Bower 804-827-3285

Statistical data on the operational experiences of wide-bodied jet transports collected prior to closure of the NASA VGH transport program will be analyzed and reported. Since no other operational flight data of this type exist for wide-bodied transports, this analysis will provide: (1) a means to study the operational changes in these practices from procedures followed with smaller jet transports, (2) an assessment of the effect of atmospheric turbulence on heavier aircraft with respect to frequency of occurrence and magnitude, and (3) a comparison of gust and maneuver loads with design gust and maneuver loads.

**W77-70103** **505-08-26**
Langley Research Center, Langley Station, Va.
**AIRCRAFT CONTROL UNDER ADVERSE FLIGHT CONDITIONS**
J. E. Stitt 804-827-3745

The objective of this investigation is to develop optimal control techniques for autopilot-autothrottle to compensate for wind-shear effects. Various types and magnitudes of wind shear will be considered and the pilot's prior knowledge or lack of knowledge of wind shear conditions. Analytical and simulator studies of methods for stabilizing helicopter sling loads will be conducted. Modern control theory will be used to optimize the control system for each concept. Safety aspects such as optimal autorotation entry and landing flare from 'dead man's' area, are to be studied. Response of aircraft to turbulence will be studied to estimate characteristics of turbulence, from aircraft responses. The research will be implemented by developing a math model for a large transport (such as the B-747) and its autopilot-autothrottle systems. Analytical studies of the dynamic response of the aircraft as it encounters various wind-shear profiles will be made to develop optimal control strategies to avoid undesirable motions of the aircraft. Aero and mechanical means of stabilizing and controlling helicopter sling loads will be examined and simulator studies of concepts that appear to be promising will be made. Flight tests for final verification will be used. Practical methods of storing more energy in rotors, and of adding energy after engine failure, to make landing less critically dependent on pilot skill will also be investigated. Calculations of power spectral density of aircraft responses to turbulence and measurements of gust intensities and aircraft responses will be made. Finally we will determine aircraft transfer function from this input-output information.

**W77-70104** **505-08-27**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**FIRE SAFETY - ENCLOSURE MODELING**
R. R. McDonald 213-354-6186

The objective of this investigation is to characterize fire development and variability in enclosures in order to formulate stability parameters and analysis criteria for application to fire testing, to enclosure design, and to fire control and suppression. These objectives would be accomplished under the following four task items: (1) characterize fire development and variability factors using available analytical studies and experimental data from enclosure fires to formulate stability criteria and periodicity parameters; (2) develop a simplified analytical model of an oscillating enclosure fire; (3) conduct an experimental enclosure fire program to validate and demonstrate the various fire variability parameters and determine their ranges of applicability; (4) develop an integrated set of enclosure fire descriptive parameters to facilitate prediction and evaluation of potential fire hazards in existing enclosures and provide criteria for enclosure design and testing.

**W77-70105** **505-08-30**
Langley Research Center, Langley Station, Va.
**CROSSWIND LANDING FOR STOL OPERATIONS**
R. E. Bower 804-827-3485

The objective is to investigate STOL crosswind landing problems and methods of extending the crosswind limits for landing. A research-type crosswind landing gear and lift spoilers will be installed on the NASA Twin Otter airplane under contract. A flight program will be conducted to evaluate and demonstrate the effectivenss of the lift spoilers and several modes of crosswind landing gear operation.

**W77-70106** **505-08-31**
Ames Research Center, Moffett Field, Calif.
**AIRCRAFT SYSTEMS OPERATIONAL SAFETY AND EFFICIENCY IMPROVEMENT**
D. R. Chapman 415-965-5065

The objectives are to improve aircraft safety and efficiency on the runway through the utilization of advanced materials incorporated in aircraft tires, to develop and evaluate new elastomer formulations for use in tires on high performance aircraft having wear and safety characteristics superior to those of state-of-the-art tires. Thermal-oxidative degradation and basic wear mechanisms of state-of-the-art and candidate tire tread elastomers will be investigated. Tread vulcanizates of new and improved elastomers in polyblends with natural rubber and/or cis polybutadiene will be evaluated with respect to wear and dynamic properties. A sample of 50 aircraft tires will be fabricated for flight testing and evaluation in airline service. In addition, tire tests will be conducted at Langley to establish relationship between runway surface and tire compositions.

**W77-70107** **505-08-31**
Langley Research Center, Langley Station, Va.
**AIRCRAFT GROUND PERFORMANCE**
R. R. Heldenfels 804-827-2042

The objective is to establish new concepts and techniques in aircraft landing gear systems and subsystems design, testing, and operation which will permit increased operating efficiencies. Aircraft operations on prepared runways under adverse weather conditions and on certain unprepared surfaces present requirements of braking and steering systems, tires, and runway that are vital to aircraft safety and passenger comfort. The objectives of programs covered by this RTOP are: (1) to improve the performance of braking systems, (2) to improve the wet performance and lifetime of pneumatic tires, (3) to develop new landing gear systems that would permit operations on unprepared fields, including water, and permit continuous use of prime runways for all-weather operations, (4) to evaluate tire cornering behavior with and without braking such that high-speed turnoffs can be designed to increase the flow of traffic at congested airports, and (5) to relate the character of the runway surface to aircraft braking and steering performance. Research to meet these objectives will employ full-scale aircraft, landing gear systems and subsystems, and scaled pneumatic tires. The test facilities will consist of the landing loads track, airport runways, including the landing research runway at Wallops Flight Center, ground test vehicles, flight-type aircraft simulators, and various laboratory equipment.

**W77-70108** **505-09-11**
Langley Research Center, Langley Station, Va.
**HUMAN RESPONSE TO NOISE**
R. R. Heldenfels 804-827-2042

The objective is to develop aircraft noise criteria and noise reduction procedures for achieving greater community acceptability. Research studies will include laboratory tests to subjectively evaluate the properties of aircraft-generated noise that are responsible for causing individual annoyance and field studies to examine the broader problems of community annoyance including psychological and sociological factors. The LaRC Aircraft Noise Reduction Laboratory will be the focal point for much of the research and will include human response studies of recorded and synthesized aircraft noise. The effects of background noise, impulsive noise, duration, noise-induced vibrations, and multievent noise exposures will be examined. Additional laboratory and field studies will examine the importance of fear, sleep, day/night exposure, and subject background in quantifying the effects of noise on people. A portion of this research will be focused on the effects and quantification of supersonic transport and helicopter noise.

**W77-70109** **505-09-12**
Ames Research Center, Moffett Field, Calif.
**ACCEPTANCE OF AIRCRAFT OPERATIONS - TECHNOLOGY ASSESSMENT**
H. P. Klein 415-965-5094
(504-09-11)

The objective of this program is to develop an understanding of the social and psychological effects of large scale technological innovations, as exemplified by air transportation systems, and to attempt to model such effects so as to impact the design of these systems. Studies of both the short and long term social impacts (including psychological, political, environmental, and economic) of air transportation as an element of the total transportation system will be continued. Field studies of existing systems such as the Dallas-Fort Worth Regional Airport and other regional airports, will be conducted as needed to meet

the objectives. Supporting work developing theory and methodology for assessing community acceptance of aircraft operations and social and psychological impact of related technologies will be conducted.

**W77-70110** **505-09-13**
Langley Research Center, Langley Station, Va.
**AIRCRAFT INTERIOR NOISE REDUCTION**
R. R. Heldenfels 804-827-2042

The objective is to develop the technology needed to reduce interior noise levels to achieve increased operating safety, hearing protection, and comfort of crew and passengers with minimum weight and cost penalties. The noise sources for STOL, helicopter, and general aviation aircraft will be determined from this as well as other ongoing programs. In addition, the transmission of the noise through the structure and the transmission paths will be determined. Structural designs will be investigated which have more acceptable transmission characteristics with minimum weight penalties. A parallel effort will determine acceptable levels of interior noise for safety and comfort of crew and passengers. Fullscale flight tests will be made incorporating noise reduction concepts to verify the technique and the passenger/crew acceptability.

**W77-70111** **505-09-21**
Langley Research Center, Langley Station, Va.
**RIDE QUALITY**
R. R. Heldenfels 804-827-2042

The objective is to define and quantify those properties of the crew/passenger environment, including motion, cabin noise, and vibration, that determine ride quality and/or passenger acceptance of air transportation systems. Research studies will include laboratory tests to subjectively evaluate the effects of aircraft vibration and interior noise on ride quality and field studies to examine the broader problems of crew/passenger acceptability. The LRC Passenger Ride Quality Simulator will be the focal point for much of the research and will include response studies of both noise and vibration. The effects of vibration frequency, direction (axis) and the interaction of noise and vibration will be quantified. In addition, other laboratory and field studies will examine the response of crew and passengers in terms of speech interference, communication, and comfort, to a number of noise and vibration stimuli. Research will be focused on general aviation, helicopter, and supersonic transport environments.

**W77-70112** **505-09-22**
Ames Research Center, Moffett Field, Calif.
**RIDE QUALITIES CRITERIA VALIDATION/PILOT PERFORMANCE DURING LOW ALTITUDE HIGH SPEED FLIGHT**
M. Sadoff 415-965-5728
(504-09-06)

The OAST Centers have begun to evaluate the B-1 airplane for possible research areas which will contribute to advanced technology of interest to NASA. The B-1 is considered to be an available test facility providing flight information not readily available from other sources. Tentative research areas have been identified as follows: Structural Mode Control/Ride Quality; Pilot Performance During Manual Terrain Following; Transonic Aeroelastic Loads Measurement; Flight Loads Measurement and Instrumentation Methods; Inlet/Engine Compatibility; AFT Nacelle Aerodynamics; and New Subcritical Flutter Prediction Technique. This RTOP is for the Ride Qualities Criteria Validation/Pilot Performance During Low Altitude High Speed Flight only. The technical consultant from ARC is listed above. Specific objectives are to: (a) validate/refine current ride qualities criteria, and (b) develop pilot/vehicle systems models which account for the effects of ride qualities, handling qualities and display configuration on pilot terrain - following performance. Results from ongoing and planned NAR simulation and flight-tests will be analyzed with the above objectives in mind. If practicable, NASA recommendations regarding simulator and/or flight experiment protocol and instrumentation will be implemented to maximize utility of results for NASA objectives.

**W77-70113** **505-09-31**
Langley Research Center, Langley Station, Va.
**FLIGHT MANAGEMENT SYSTEMS**
J. E. Stitt 804-827-3745
(513-52-01)

The objective is to define the crew responsibilities, flight procedures and control and display requirements for advanced transport systems. The concerted effort underway to improve the safety and efficiency of advanced transport systems requires research in both hardware and human elements to systematically carry out the above objective. Therefore, the present work will take the following approach: (a) continue to develop tools and techniques that will define the crew responsibilities and measure their workload, (b) apply these tools and techniques to assess current and contemplated flight systems, and (c) develop analytical techniques that will assess advanced system requirements and human operation and predict cockpit displays and controls needed for a satisfactory flight management system.

**W77-70114** **505-09-32**
Ames Research Center, Moffett Field, Calif.
**AIRCREW PERFORMANCE AND AVIATION SAFETY**
H. P. Klein 415-965-5094
(515-51-11; 504-09-33; 505-08-23)

This program will investigate current problems in pilot training, performance measurement and evaluation, and communications between flight crew members and other components of the aviation system. Civil aviation operations will be considered. Specific objectives are: (1) to develop objective, precise, and stable measures of aircrew performance for use in research and operational training programs, (2) to develop new technology and methodology for training necessary flight crew skills, (3) to explore fundamental problems in the transfer of information to pilots from other components of the aviation system, e.g., navigation charts, aircraft and flight operating manuals, and cockpit warning systems, and (4) explore fundamental characteristics of human cognitive and decision-making behavior and their relationships to pilot performance. A GAT-1 simulator is being modified to permit full-mission simulation capability and automated performance monitoring. This facility is being used to examine pilot behavior, especially cognitive or decision-making behavior, and to evaluate alternative methods of human performance measurement. The effectiveness of various candidate solutions for identified training problems will be evaluated using both formal experimental evaluations, and more informal feasibility demonstrations (pilot projects). Fundamental problems in the transfer of information between pilots and other components of the present aviation system will be identified and potential solutions will be developed and evaluated.

**W77-70115** **505-09-33**
Ames Research Center, Moffett Field, Calif.
**FLIGHT MANAGEMENT SYSTEMS - AIRCREW SUPERVISORY CONTROL FUNCTIONS**
H. P. Klein 415-965-5094
(504-09-32; 515-51-11)

This program will investigate flight management and crew/system interaction mechanisms and requirements for advanced aircraft. Emphasis is on the roles of the aircrew and ground personnel in a highly automated system. The objectives are to develop procedures for the measurement and assessment of advanced aircrew supervisory control performance under varied conditions of automation, ground authority, traffic complexity and environmental hazards, develop principles of optimal crew utilization which maximize behavioral effectiveness and minimize stress factors which produce human errors, and explore new technology for improved man-system information interfacing and advise the aviation community of potential for current applications. A full-mission advanced aircraft cockpit facility will be used to create a series of 3D and 4D area-navigation environments in which to study the aircrew's ability to plan or modify flight plans and monitor system performance. These studies, in conjunction with University grants concerned with human decision-making and supervisory control models, will be used to develop principles of optimal crew utilization. Collaborative studies with U.S. industry and military organizations are being pursued

to investigate the utility of speech synthesis and automatic speech recognition systems in current civil and military aircraft operations.

**W77-70116** **505-09-34**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**FLIGHT MANAGEMENT IN REMOTE PILOTED SYSTEMS**
W. R. Winter 805-258-3311

This flight test program is primarily to develop and evaluate an integrated system for pilot control of remote piloted vehicles. The pilot task load will be analyzed and correlated with the psychophysiological response of the aircrew during the development of the RPV system. The general objective is to define operator/system interactions, flight procedures in control and display requirements for remote piloted vehicles to be used as training simulators and as active flight vehicles. The specific objectives are to (1) define and correlate major workload with observed response to form predictive performance models, and (2) evaluate RPV cockpit configuration, pilot responses, and display and control variations to optimize (a) simulation effectiveness and (b) remote operation efficiency to include horizontal landing. While developing and utilizing RPV techniques, cockpit configurations will be systematically varied while the effects upon pilot response are tabulated.

**W77-70117** **505-09-41**
Langley Research Center, Langley Station, Va.
**APPLICATION OF FLIGHT SIMULATION TECHNOLOGY**
James E. Stitt 804-827-3745

The objective is to apply simulation technology to existing flight simulators to support Langley research programs. This RTOP will cover both in-house and contractual studies which address current constraints in Langley simulator equipment, in the formulation and validation of simulation math models, and in the linkage of the hardware software systems to provide, in the closed-loop pilot/simulator environment, effective simulations. Principal tasks for FY-77 include studies of model requirements for RSRA simulation, evaluation of kinesthetic cues for DMS, development of improved real-time simulation computing techniques for the Real-Time Simulation System and validation of the man-machine systems model for analysis of flight simulator engineering requirements. Results of the effort will be documented in NASA Technical Notes and contractor reports, and will be applied to simulations of interest to Langley Research Center.

**W77-70118** **505-09-42**
Ames Research Center, Moffett Field, Calif.
**SIMULATION TECHNOLOGY FOR AERONAUTICS**
H. P. Klein 415-965-5094
(504-09-32; 504-09-33)

The objectives of this RTOP are to provide a scientific and technical base of information that can be used as a resource to develop valid, reliable and economical simulators for aeronautical research, development and crew training. Specific objectives are: to develop advanced hardware and software concepts for high fidelity simulation of vision, motion and aural environments; to evaluate existing and prototype simulator systems using comprehensive psychological and engineering assessment techniques; and to develop task related fidelity criteria for simulators based on a detailed analysis of human operator requirements and engineering principles. (1) Perception and human performance studies will be continued in-house with an emphasis on developing task related fidelity criteria and associated methods for measuring the fidelity of simulators; (2) existing simulators and simulator subsystems will be evaluated utilizing both traditional assessment methods and the new techniques developed in (1); (3) promising new visual scene technology development will be continued in-house; and (4) contractual and in-house studies will be initiated to develop new or improved computational methods and software systems for visual scene generation, motion system logic, and the high fidelity simulation of aural cues.

**W77-70119** **505-10-11**
Langley Research Center, Langley Station, Va.
**GENERAL AVIATION - AERODYNAMICS**
804-827-3285

The objective is to develop and demonstrate advanced technology that will permit the design of general aviation aircraft that are safer, more productive, and clearly superior to foreign competition. This work will be accomplished by analytical studies, model tests, and flight tests to develop and demonstrate improved airfoil sections, wing designs, control characteristics, handling qualities, stall/spin characteristics, drag reduction, ride comfort, and pilot information.

**W77-70120** **505-10-12**
Ames Research Center, Moffett Field, Calif.
**AERODYNAMIC PERFORMANCE TECHNOLOGY FOR THIRD-LEVEL CARRIER AIRCRAFT**
L. Roberts 514-965-5567

The objective is to provide advanced technology that will permit the design of future aircraft that are safer and more productive. Stall characteristics of existing aircraft will be improved through wind-tunnel testing of various aerodynamic and control system modifications. In addition, promising future aircraft configurations will be studied which have potential for inherent or imposed stall/spin immunity. The engine cooling drag requirements of typical high-performance third level carrier aircraft will be analyzed and methodology for their improvement developed. Thus, the climb-cruise performance will be improved, the engineering manhours required for the development of any particular design will be decreased, and allowances will be available for the increased cooling requirements occasioned by stricter pollution and fuel economy regulations. A user-oriented airfoil design code utilizing numerical optimization techniques will be developed which will allow the aircraft designer to optimize the airfoil sections subject to appropriate constraints.

**W77-70121** **505-10-13**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**GENERAL AVIATION AERODYNAMICS AND FLIGHT DYNAMICS**
S. W. Gee 805-258-3311
(505-07-21)

The technical objective of this research will focus on identification and demonstration of optimum levels of stability control, and handling qualities for general aviation aircraft that can be achieved through the application of advanced technology; the use of a free canard or free stabilizer to control the angle of attack of a wing which is free to pivot about a spanwise axis will be investigated. Flight and simulator studies will be continued in control display interactions. The economical mechanization of attitude command control on the Beech 99 airplane will be flight tested. The many potential advantages of, and the feasibility of implementation of a free wing concept is being explored. A free trimmable canard or free stabilizer will be designed to limit the operation of the free wing to a range of desired angles of attack.

**W77-70122** **505-10-14**
Wallops Station, Wallops Island, Va.
**SAFETY ANALYSIS OF UNCONTROLLED AIR TRAFFIC FLOW DYNAMICS FOR GENERAL AVIATION AIRCRAFT**
Loyd C. Parker 804-824-3411

The objective is to collect and analyze general aviation piloting procedures and aircraft flight dynamics data to define significant performance and operational parameters during landing approach and departure from airports. A data base has been collected which is comprised of over 3,000 three dimensional radar tracks of arrival and departure flight profiles and the corresponding environmental conditions which existed for each flight. Math models for the analysis and quantitative definition of pilot and aircraft performance and piloting procedures have been developed. Math models for analysis of the mid-air collision hazard in uncontrolled airspace, simulation of existing air traffic and for assessment of new air traffic pattern concepts have also been defined and prototype models demonstrated. Utilizing these models, pilot procedures will be characterized for various aircraft type and environments and simulations of various uncontrolled traffic pattern concepts conducted to minimize the mid-air collision hazard and improve community noise exposure created by present patterns.

**W77-70123** **505-10-21**
Ames Research Center, Moffett Field, Calif.
**HELICOPTER AERODYNAMIC PERFORMANCE, DYNAMICS AND NOISE**
C. T. Snyder 415-965-5567
(505-10-22; 791-93-22)

This RTOP covers joint NASA/Army research on all aspects of rotor aeromechanics (that is performance, dynamic loads, stability, control system, and noise characteristics) of advanced edgewise-flying rotor concepts and configurations. Analyses will be followed by large scale wind tunnel tests to evaluate these configurations and to provide a data base to improve analytical techniques. An additional transmission will be accepted for the Rotor Test Apparatus (RTA) for high-torque, low RPM operation necessary for large diameter rotors. The RTA module will be calibrated for quantitative determination of dynamic loads. The design and fabrication of an advanced research rotor will be initiated. This rotor will incorporate latest concepts of rotor airfoils, camber, and twist, etc. and will be used to evaluate helicopter aeromechanics prediction methods. The controllable twist rotor will be tested with multicyclic control for vibration/stress suppression to determine performance/stress trade-offs. Research on rotor noise generation, its mechanism and source location, and relation to blade/vortex interaction will continue. A rotorcraft drag reduction study will begin starting with model and/or full scale tests of hub-pylon-fuselage configurations to develop predictive techniques. Design and fabrication of optical elements for a laser velocimeter for application to rotor inflow studies in the 40- by 80-foot wind tunnel will be continued.

**W77-70124** **505-10-21**
Langley Research Center, Langley Station, Va.
**HELICOPTER AERODYNAMICS**
R. E. Bower 804-827-3285
(505-10-23; 505-10-26; 514-53-01; 505-06-31)

Analytical and experimental studies will be made to identify factors contributing to the aerodynamic and structural characteristics of rotors. University grants and contracted studies will be continued to define wake geometry and analytical procedures which include wake characteristics in predicting airloads, structural response, and aerodynamic performance. In-house experimental studies will be continued to better define unsteady local-flow parameters significant in the prediction of rotor blade section lift and drag. Analytical, wind-tunnel, whirl tower, and flight investigations will be made to determine performance, dynamic loads, vibrations, and wake flow characteristics of advanced rotor concepts, rotorcraft configurations, and tail rotor arrangements. These studies will be coordinated with the airfoil development research under RTOP 505-06-31, with the rotor aeroelastic and acoustic studies under RTOP 505-10-26, and with rotor systems development under 514-53-01. These programs will, in general, be carried out jointly with the Langley Directorate of the Army Air Mobility Research and Development Laboratory.

**W77-70125** **505-10-22**
Ames Research Center, Moffett Field, Calif.
**TILT ROTOR AIRCRAFT AERODYNAMIC PERFORMANCE, DYNAMICS, AND NOISE**
C. T. Snyder 514-965-5567
(505-10-21)

This RTOP covers activity in research and technology for tilt rotor aircraft to provide a sound base for definition of performance, dynamic loads, stability, control system, and noise characteristics of advanced tilt rotor concepts and configurations. In FY-77, the XV-15 aircraft will be tested in the 40- by 80-foot wind tunnel. The in-house dynamic stability theory will be refined and applied to the XV-15 test. Contracted analyses and tests will be continued to determine tilt rotor gust response and means for gust alleviation and blade load suppression. Contracted investigation of rotor dynamic stability measurement techniques will be continued.

**W77-70126** **505-10-23**
Ames Research Center, Moffett Field, Calif.
**ROTORCRAFT FLIGHT DYNAMICS**
C. T. Snyder 415-965-5567

A joint NASA/Army investigation will be made of the interaction between, and relative importance of helicopter stability and control characteristics, displays, and pilot workload on performance of specific military and civil tasks (low-level operations such as nap-of-the-earth maneuver and pipeline surveillance; terrain masking and unmasking; low light level operations; bob-up and weapons firing). The objective is to provide a data base to quantify the tradeoffs between system complexity and task performance so that cost effective design decisions can be made in the implementation of hardware devices. Fixed and moving-base piloted simulations will be used to evaluate task performance. Selected results will be verified with flight experiments using a variable stability helicopter as an in-flight simulator. The application of advanced control systems to tilt rotor aircraft will be examined, through analysis, piloted simulations and flight experiments in the Tilt Rotor Research aircraft.

**W77-70127** **505-10-23**
Langley Research Center, Langley Station, Va.
**ROTORCRAFT FLIGHT DYNAMICS**
R. E. Bower 804-827-3285
(513-54-02; 513-54-03; 505-07-41)

The objective is to use broad capability helicopter in-flight simulators, as primary tools, to conduct research required to develop improved criteria (primarily in the areas of handling qualities and overall flight characteristics) for the various classes of VTOL vehicles as well as for helicopters and other rotorcraft. The scope of the research includes consideration of manual IFR flight conditions, as well as consideration of advanced vehicles having automatic and active control capability with satisfactory provision for pilots to monitor and take over flight control manually with particular emphasis on flight in the terminal area. Representative types of problems to be investigated include defining the requirements and flight/operational characteristics of advanced flight control systems, including active controls, inherent and augmented stability, cockpit displays, pilot controls, vehicle/pilot interfaces with ground-based and onboard navigation systems for manual flight in IFR conditions, and vehicle/pilot interfaces with automatic flight systems. The VALT CH-47 has been instrumented to provide a highly flexible and efficient replacement for the CH-46 in-flight simulator to explore these areas. The SH-3A will be used for cockpit display/pilot workload studies. In addition, analytical studies will be conducted to define the impact of rotorcraft design parameters on the capability to implement high-gain control concepts in large helicopters.

**W77-70128** **505-10-24**
Langley Research Center, Langley Station, Va.
**ROTORCRAFT CIVIL HELICOPTER TECHNOLOGY**
R. E. Bower 804-827-3285
(505-10-21; 505-10-23; 505-10-26)

The objectives are: (1) to identify, in critical disciplinary areas, the projected requirements and associated criteria for achieving successful and acceptable civil operations, and to evaluate existing vehicles in meeting these requirements, (2) to assess the extent to which existing advanced technology can be applied to meet projected requirements, and to identify areas requiring additional research, (3) to conduct vehicle and systems design application studies utilizing existing advanced technology, and (4) to carry out key experimental evaluations which are deemed critical to industry acceptance and use of promising advanced technology features. Studies will be carried out both through analytical, design, and systems studies and through experimental evaluations of selected systems in simulated operational environments. The program will utilize principally contractual effort, plus some in-house effort in flight research experiments.

**W77-70129** **505-10-26**
Langley Research Center, Langley Station, Va.
**ROTOR ACOUSTICS AND AEROELASTICITY**
R. E. Bower 804-827-3285
(505-10-21; 505-10-25)

The objective of this plan is to develop technology related to aeroelastic and noise characteristics of rotors, and to use this technology in developing and validating adequate design prediction methods. Technical areas of interest include methods

of predicting aeroelastic stability characteristics of rotors in hover and forward flight, vibration characteristics of helicopters and means for reducing or alleviating excessive vibrations, unsteady rotor aerodynamics noise source identification, improved noise prediction techniques, and means for helicopter rotor noise control. The generalized rotor aeroelastic model will be used to evaluate aeroelastic characteristics of variable geometry rotor for RSRA, to determine dynamic stall characteristics of AH-1G Cobra rotor, and support a cooperative research program using Sikorsky S-70 rotor. Tests will be conducted using the GRAM to evaluate higher harmonic control as means for reducing fuselage vibration levels. Several grants for aeroelastic stability and vibration analyses will be continued. The problem of noise prediction will be investigated experimentally in-house using overflights for NASA AH-1G and UH-1H helicopters in conjunction with ANRD IFAMS and ROMAAR systems. Further data analysis will be purchased from Bell Helicopter Co. on flight program previously funded in part by ANRD. In-house effort is anticipated in the area of high frequency fluctuating blade loads and high speed effect of airfoil thickness distribution on the radiated noise. Various tip vortex modification schemes will be evaluated analytically and experimentally to determine their effectiveness in reducing rotating blade noise.

**W77-70130** **505-10-27**
Ames Research Center, Moffett Field, Calif.
**ADVANCED TILT ROTOR AERODYNAMICS**
W. H. Deckert 415-965-5887
(514-50-01)

The objective of this effort is to provide technical data to enable rotor and control system design optimization for advanced tilt rotor aircraft. Design information for control systems that will maximize aircraft maneuver capability, reduce rotor loads, and reduce tilt rotor sensitivity to gust and turbulence will be developed. The lateral and longitudinal gust responses and their alleviation in an Advanced XV-15 tilt rotor aircraft with a hingeless composite rotor system will be investigated using previously developed mathematical models.

**W77-70131** **505-10-31**
Ames Research Center, Moffett Field, Calif.
**VTOL AERODYNAMIC PERFORMANCE**
C. T. Snyder 415-965-5567
(505-03-12)

This RTOP covers research on the aerodynamics, performance, stability, and control of promising jet-lift VTOL transport and fighter configurations including a better understanding of propulsion-aerodynamic interactions. Analytical methods for predicting these characteristics will be improved. Studies of advanced augmentors at both large and small scale will continue. This includes flow surveys and factors which affect mixing rate. Large scale tests of ejector fighter designs will be made. Theoretical and experimental studies of transition performance of lift/cruise fan powered VTOL aircraft will continue. The configurations will include both the deflector and split flow type. Prediction methods will include the effects of separated flow.

**W77-70132** **505-10-32**
Ames Research Center, Moffett Field, Calif.
**VTOL FLIGHT DYNAMICS**
C. T. Snyder 415-965-5567
(505-10-35)

Design and handling qualities criteria will be developed for satisfactory manual control of jet or lift-fan VTOL aircraft. Two areas are of primary concern. The first is to develop advanced flight control systems that overcome deficiencies of existing systems designed for these aircraft. The second is to study and solve specific problems associated with adapting VTOL aircraft to operations from ships. A particular advanced controller concept, called the state rate feedback implicit model follower will be implemented in a simulation of the NASA/Navy Lift/Cruise Technology Aircraft and evaluated over the entire powered-lift flight envelope. Flight research, in the hovering mode, using the X-14B aircraft, will also be employed to study advanced control concepts. Piloted, moving-base simulation will also be employed to study special manual control problems in the take-off, approach, and landing of VTOL aircraft from Navy ships during severe weather conditions. The techniques developed will be employed in simulations required for the NASA/Navy Lift/Cruise Technology Aircraft Program (RTOP 505-10-35) as well as in simulations to meet the objectives of this RTOP.

**W77-70133** **505-10-35**
Ames Research Center, Moffett Field, Calif.
**NASA/NAVY MULTIMISSION V/STOL AIRCRAFT TECHNOLOGY DEVELOPMENT**
W. H. Deckert 415-965-5903
(514-50-02)

This RTOP is to cover the Technology Development Programs, Phase I Lift/Cruise Fan Design, and Phase I Aircraft Preliminary Design for NASA/Navy Lift/Cruise Fan Research and Technology Aircraft (LERTA). The program is being cofunded by the U.S. Navy. Lewis Research Center is supporting the technology programs related to the lift/cruise propulsion system. This research aircraft will have V/STOL capability provided by integrated propulsion/control system having lift/cruise fans for hover and the cruise modes of flight. The development of the technology would allow proceeding with the lift/cruise fan development in FY 76 followed by Aircraft Preliminary Design in FY 77 and a New Start for the development of the LERTA Aircraft in FY 78. The Technology Development Program includes (1) small-scale and large-scale low speed wind tunnel tests, (2) static tests of large-scale thrust deflectors, (3) conceptual design studies of the research and technology aircraft, (4) small scale high-speed wind tunnel tests, (5) simulation of the potential research aircraft, and (6) variable pitch fan wind tunnel tests.

**W77-70134** **505-10-36**
Ames Research Center, Moffett Field, Calif.
**VTOL MILITARY AIRCRAFT CRUISE AND MANEUVER AERODYNAMICS**
Richard H. Petersen 415-965-5881
(505-04-11; 505-10-43)

The objective of this new RTOP is to develop aerodynamic technology in support of military VTOL aircraft, especially the fighter, attack, and interceptor aircraft required by the U.S. Navy for airborne capability in its future surface fleet. The success of VTOL aircraft as military vehicles will be dictated by their performance and efficiency which will depend upon the efficient integration of advanced aerodynamic technology into VTOL aircraft. To achieve this, the research under this RTOP will be devoted to the development of analytical methods, experimental techniques, and a data base to support the aerodynamic development of VTOL aircraft. Several aircraft configurations will be defined with the assistance of industry and the military. Existing techniques for aerodynamic analysis and experimental evaluation will be applied to identify promising concepts. To develop further understanding and capability, new approaches in aerodynamic analysis, experimental methods, and aerodynamic design will be initiated. These approaches will include the use of linear and nonlinear finite element aerodynamic techniques in combination with new techniques for defining configurations and acquiring experimental data. Emphasis will be placed on the cruise and maneuver flight conditions; however, consideration will be given to the low speed aspects of the problem to ensure compatibility throughout the Mach number range. Specific attention to takeoff, landing, hover, and transition will be addressed in RTOP 505-10-31.

**W77-70135** **505-10-41**
Ames Research Center, Moffett Field, Calif.
**STOL/RTOL LOW-SPEED AERODYNAMICS**
C. T. Snyder 415-965-5567
(505-06-23)

This RTOP covers Ames efforts in R/STOL low-speed aerodynamics and noise. The goal is to provide the high lift technology, both powered and unpowered, for civil and military short-haul aircraft, and the noise technology for powered lift systems. For FY 1976T and FY 1977, it is planned to support QSRA activities, develop thrust reversers for upper surface blowing concepts, perform in house studies on augmentors, and study

the advantages of powered lift technology for carrier aircraft. Advanced theoretical techniques will be used to design a three-dimensional high lift wing. Improvement in wind tunnel test techniques will also be studied.

**W77-70136** **505-10-42**
Ames Research Center, Moffett Field, Calif.
**STOL/RTOL FLIGHT DYNAMICS**
C. T. Snyder 415-965-5567

Generalized analytical studies, ground-based simulation, and flight research will provide data for revision and extension of existing handling qualities and certification criteria for STOL aircraft. The data will apply to the following critical areas: flight-path, airspeed, and attitude control; landing flare in presence of ground effect; roll and yaw control for cross-wind landing; and the control of a powered-lift STOL following loss of an engine. Tentative airworthiness criteria, together with techniques for determining compliance will be developed in cooperative FAA/NASA piloted simulation studies on the Flight Simulator for Advanced Aircraft. These results will contribute to generalized criteria for all concepts. Implications for transport aircraft design will be drawn from the criteria. Flight research in both handling qualities and certification areas will be accomplished using the Augmentor Wing Jet STOL Research Aircraft; a DHC-6 aircraft equipped with hinged-plate spoilers(joint NASA/FAA program); and the QSRA, YC-14 and YC-15 aircraft as they become available. A simulation experiment will be conducted to develop means and procedures for reducing landing field length and increasing precision and safety of the landing approach under adverse weather conditions for short-haul RTOL aircraft.

**W77-70137** **505-10-43**
Ames Research Center, Moffett Field, Calif.
**R/STOL CRUISE AERODYNAMICS**
Richard H. Petersen 415-965-6396

The objective of this research is to evaluate and improve the cruise performance characteristics of R/STOL short-haul aircraft. This is an expansion of the effort described in the FY 76 version of this RTOP entitled STOL Cruise Augmentor, which concentrated solely on the cruise augmentor. The new emphasis will be placed on developing predictive techniques and a data base to improve the performance and integration of the basic components and the overall aircraft. Current program objectives include: (1) the optimization of the cruise augmentor for jet STOL, and (2) efficient integration of advanced technology propellers and wings for future fuel-efficient transports. Emphasis will be placed on the development of analytical techniques for predicting the performance characteristics of these concepts. Experimental programs are planned to acquire the necessary data base to develop design guidelines and to verify the analytical procedures.

**W77-70138** **505-10-44**
Langley Research Center, Langley Station, Va.
**AEROACOUSTICS AND LOADS**
R. D. Bower 804-827-3285

This RTOP covers research on aeroacoustic and loads problems for conventional and advanced design commercial aircraft. The objective is to provide the technology required to reduce community and interior noise and to define the external flow fields and associated loads. Research begun in previous years relating to EBF and USB configurations will be completed. The scope of the activity will be broadened to address noise and acoustically induced loads problems common to a wide class of vehicles and configurations including CTOL and O-T-W engine location. Short haul related activities will be closely coordinated with Ames Research Center. Inhouse and contract efforts will provide data and prediction methods pertaining to acoustic and loads phenomena. Studies will be made on large and small scale models. Scaling laws for jet impingement induced structural loads will be derived and verified. The production of trailing edge noise will be studied experimentally and means for controlling it through the use of surface porosity will be estimated. Studies of shielding benefits of over-the-wing engine location will be undertaken. Efforts will begin to explore the use of signal processing techniques to enable good acoustic measurements to be made in the V/STOL wind tunnel. Fluctuating surface pressures measured on a 1/4-scale model of the YC-14 will be analyzed and used to derive scaling laws for acoustic loads. A computer program will be implemented for predicting interior noise in pilot and passenger compartments of aircraft.

**W77-70139** **505-11-11**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**OBLIQUE WING LOW SPEED FLIGHT RESEARCH**
P. C. Loschke 805-258-3311
(505-11-12; 505-11-16)

An exploratory low speed flight study of the piloting characteristics of oblique wing aircraft is proposed, using a low cost experimental manned jet-powered model. The following objectives have been selected with a view to providing a basic framework of data and flight experience for planning a more comprehensive transonic evaluation of the concept using a TF-8 aircraft: (1) to identify the dynamic characteristics of an unsymmetric aircraft due to pilot control and gust inputs, including a pilot assessment of handling qualities in relation to conventional aircraft; (2) to ascertain whether a simple mechanical flight control system will provide satisfactory levels of handling and flight safety; (3) to acquire sufficient airplane response data to verify the methods used to predict the behavior of oblique wing aircraft; and (4) to assess generally the nature and complexity of flight control and systems requirements to be anticipated in the development of future oblique wing transports.

**W77-70140** **505-11-12**
Ames Research Center, Moffett Field, Calif.
**HIGH SUBSONIC/TRANSONIC AIRCRAFT AERODYNAMIC PERFORMANCE**
Richard H. Petersen 415-965-6272
(505-06-11)

The objective of this investigation is to determine the aerodynamic performance and stability and control characteristics of aircraft configurations at high subsonic and transonic speeds, and to provide adequate aerodynamic prediction methods for this class of vehicles. Currently, the experimental investigation of promising oblique wing configurations and wing geometries are being analyzed and compared to analytical predictions and will be reported during FY 77. This will terminate the oblique wing research effort.

**W77-70141** **505-11-13**
Ames Research Center, Moffett Field, Calif.
**OBLIQUE WING FLIGHT TEST TECHNOLOGY**
Richard H. Petersen 415-965-5881
(505-11-11; 516-50-10)

The primary objective of this project is to develop and improve analytical and empirical prediction techniques that will provide more accurate estimation of aircraft dynamic flight behavior from static wind tunnel data. Investigations of the currently used methods for predicting dynamic derivatives from static aerodynamic data and methods based on wind-tunnel/flight-data correlations will be made and effort will be made to improve these methods and develop new methods where appropriate. A remotely piloted research aircraft has been constructed, wind tunnel tested and simulated in the facilities at Ames Research Center. The vehicle is being modified at Dryden Flight Research Cente for flight test in FY 1976TQ. The data from the flight tests will be compared with estimates and ground tests and a report will be prepared describing the differences and validity in defining the aerodynamics at each phase of the project. The techniques and methods developed during this project will be used directly in the support of the AD-1 manned oblique winged vehicle flight program.

**W77-70142** **505-11-14**
Ames Research Center, Moffett Field, Calif.
**CIVIL AIRCRAFT DEVELOPMENT TESTING (FEE BASIS)**
R. H. Petersen 415-965-5848
(505-11-41)

Research and development of commercial civil aircraft generally require supporting wind tunnel investigations. In particular, Reynolds number effects on high-lift system characteris-

tics at take-off and landing speeds, and performance, stability and control characteristics and aerodynamic loads assessment at transonic and supersonic speeds need experimental evaluation. Notably the 12-foot pressure wind tunnel and the unitary plan wind tunnels are well suited for such investigations and, when technically appropriate, are utilized accordingly. Proprietary testing at the request of a particular company is charged for in accord with NASA policy.

**W77-70143** **505-11-15**
Langley Research Center, Langley Station, Va.
**HIGH-SPEED AERODYNAMICS**
R. E. Bower 804-827-3285

The technical objective of this work is to provide the analytic methodology and a background of aerodynamic data throughout the speed range (up to about M = 4.5) for defining and optimizing the aerodynamic performance of high-speed aircraft configurations. The approach to be used will employ both theoretical and experimental investigations of generalized aircraft configurations to develop techniques for increasing aerodynamic efficiency; to determine means of managing the aerodynamic center variation with Mach number, to attain low static margins without encountering regions of static instability; and, to develop new aerodynamic control concepts to provide maximum aerodynamic control effectiveness with a minimum of control force. Attempts will be made to formulate original theories and to adapt existing theories to practical usage in computing programs. Limited wind-tunnel tests will be made to verify, to establish limits of, and where appropriate, provide empirical corrections to theoretical results. Interactive computer graphics will be developed for efficient use of both manpower and computer power.

**W77-70144** **505-11-16**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**MEDIUM AND LONG HAUL AIRCRAFT AERODYNAMICS**
E. J. Saltzman
805-984-8606

The technical objectives are to provide for the evaluation of and the continued improvement of airfoils and airfoil fuselage combinations in-flight (in a real flight environment) with special emphasis on efficiency. The objectives include: (1) the development of improved methods of evaluating the relative efficiency of an airfoil or an airfoil fuselage combination, (2) the application of these methods in evaluating airfoils and new configurations, (3) evaluation of the influence of various kinds of fabrication texture and roughness on efficiency and (4) research of means and concepts which may lead to reduced aerodynamic drag, increased efficiency, with special emphasis on subsonic flight. Initially the work will be oriented toward the development of special instrumentation and techniques. The most immediate will be the development of a Wake Traverse Probe and sensor-recorder system for providing precise in-flight section drag coefficeint values. The development of a large friction balance is also a part of the approach.

**W77-70145** **505-11-16**
Langley Research Center, Langley Station, Va.
**TRANSPORT AIRCRAFT ADVANCED AERODYNAMICS**
R. E. Bower 804-827-3285
(514-57-01)

The objective is to explore advanced aerodynamic concepts required for the future development of medium- and long-haul aircraft with markedly improved characteristics. Emphasis will be directed toward innovative aerodynamic components and innovative complete configurations. In-house and contract efforts which utilize wind tunnels, acoustic laboratories, outdoor test rigs, and theoretical and analytical approaches will be directed toward providing a data base and prediction techniques pertaining to subsonic aerodynamic performance for both cruise and high-lift conditions, propulsion system integration, stability and control, and where appropriate, acoustic and loads phenomena.

**W77-70146** **505-11-18**
Ames Research Center, Moffett Field, Calif.
**CIVIL AIRCRAFT DEVELOPMENT TESTING (OTHER GOVERNMENT ORGANIZATIONS EXCEPT DOD)**
R. H. Petersen 415-965-5848
(505-11-14)

With due consideration of available manpower, funds, and obligations towards NASA research and projects, Ames supports other governmental agency and industry programs in aeronautics. The support consists of consultation, assignment of personnel to advisory committees or boards, and the conduct of tests in wind tunnels, or other facilities. The major portion of this effort is in support of the Department of Defense and is covered by RTOP 505-11-41. An additional RTOP is required, however, to cover the allotment of time to other NASA Centers and to governmental agencies other than the Department of Defense. In general, manpower and test time is allocated only when the need for special unique capabilities of the personnel or the equipment is evident, and the request is in the national interest.

**W77-70147** **505-11-21**
Langley Research Center, Langley Station, Va.
**MILITARY AIRCRAFT AERODYNAMICS**
R. E. Bower 804-827-3285

The technical objective of this work is to develop the aerodynamic technology base for the design of future military aircraft. The approach to be used will combine both analytical and experimental studies of the integration of advanced aerodynamic concepts such as supercritical aerodynamics, wing warp, maneuver devices, thrust-induced lift, and component interference in the design of complete aircraft configurations. Particular emphasis will be placed on the improvement of performance and stability-and-control characteristics in the high angle-of-attack range at subsonic, transonic, and supersonic speeds.

**W77-70148** **505-11-21**
Ames Research Center, Moffett Field, Calif.
**MILITARY AIRCRAFT - AIRCRAFT AERODYNAMICS**
Richard H. Petersen 415-965-5859
(505-04-11; 505-06-95)

Theoretical and empirical techniques will be developed to aid in the design of advanced military aircraft. Particular attention will be given to the mutual interaction effects between the basic airframe and the propulsion system. The continuing objective of this work will be to provide verified methods for predicting the interaction of airframe-propulsion system combinations in order that significant reductions in wind tunnel development time can be realized. Although a large data base exists for use in verifying predictive methods, some additional experimental testing may be necessary for verifying analytical techniques for radically different configurations or flight conditions not encompassed within the data bank. The range of variables will include forebody, inlet and afterbody geometry, inlet shape and location, as well as the usual aircraft flight variables.

**W77-70149** **505-11-22**
Ames Research Center, Moffett Field, Calif.
**HIGH MANEUVER MISSILE**
Richard H. Petersen 415-965-5859
(505-06-95)

This program was aimed at providing consistent basic knowledge, experimental tools, data, prediction methods, and theory for determining the aerodynamic and control characteristics of high-maneuver missiles for the 1980's. However, due to recent manpower cuts these efforts will be terminated by the end of FY 76TQ or in some cases moved to RTOP 505-06-95 (High Angle-of-Attack Aerodynamics).

**W77-70150** **505-11-22**
Langley Research Center, Langley Station, Va.
**MISSILE AERODYNAMICS**
R. E. Bower 804-827-3285

The objective is to provide a technology base such that maximum advantage of aerodynamic effects are realized in missile performance. Identify new aerodynamic/missile concepts and establish the data base to evaluate the performance of the concept. The approach to be used will combine both analytical and experimental techniques. Studies will provide the technology for advanced missiles at all speeds for various mission require-

ments including the aerodynamic stability and control characteristics of surface-to-air, air-to-ground, air-to-air, and surface-to-surface missiles with wing, tail, canard, or jet controls. Emphasis is to be given to aerodynamic problems of fundamental importance to a class of configurations to permit a later selection for a specific development. Studies will include rocket as well as air-breathing systems with special consideration being given to inlet-airframe integration.

**W77-70151** **505-11-23**
Langley Research Center, Langley Station, Va.
**AIRCRAFT PROPULSION INTEGRATION CHARACTERISTICS**
R. E. Bower 804-827-3285

The objective of this research is to investigate and develop the technology base required for the design and development of advanced propulsion integration concepts. This study will be pursued with the objectives of defining the effects of advanced propulsion concepts on the performance and interference characteristics of highly maneuverable and supersonic cruise aircraft. The accomplishment of the goals of this research can provide significant increases in the performance and the operational capability of future military aircraft. Advanced military type aircraft configurations will be utilized for experimental investigations of advanced propulsion concepts. The primary emphasis will be placed on innovative nozzle/afterbody concepts such as nonaxisymmetric nozzles (2-D), and dry-power supersonic-cruise nozzles for increased performance and, through thrust vectoring increased maneuverability. This research will concentrate on configurations such as the advanced tactical fighter. The experimental studies will be conducted in the 16-foot transonic, and the Unitary tunnels, and the jet exit test stand.

**W77-70152** **505-11-24**
Langley Research Center, Langley Station, Va.
**MILITARY AIRCRAFT-POWER INDUCED AERODYNAMICS**
R. E. Bower 804-827-3285

The technical objective of this work is to provide improved low-speed aerodynamic technology for advanced high performance VTOL and CTOL military aircraft. The major emphasis will be placed on the interference between power and the external aerodynamics during takeoff and landing and during high angle-of-attack maneuvering. Both fundamental jet flow field and powered configuration oriented research will be performed by means of coordinated theoretical and experimental investigations. The fundamental jet flow field effort will involve the development of mathematical models for rectangular jets. The powered configuration oriented effort will consist of the theoretical design and experimental evaluation of optimally contoured conventional CTOL transonic and supercruiser type fighters as well as VTOL fighters.

**W77-70153** **505-11-25**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**RPRV CAPABILITY DEVELOPMENT (FIREBEE II)**
P. C. Loschke 805-258-3311
(505-02-22)

This RTOP covers a Remotely Piloted Research Vehicle (RPRV) capability development program. The program will develop a baseline capability for performing flight research with supersonic, maneuverable vehicles. A capability will also be developed to conduct flight research using supersonic RPRV's as a versatile high performance research test bed. Particular emphasis will be placed on developing the existing DFRC RPRV operating systems to be compatible with these types of vehicles. A Firebee II target drone (BQM-34F) on loan from USAF has been modified to the RPRV configuration. The technique development program will consist of flying the vehicle in its performance and maneuvering envelope to meet the program objectives. The vehicle will be modified with a complete research instrumentation system along with the RPRV command and control capability. The recovery technique will utilize an updated Firebee II MARS.

**W77-70154** **505-11-26**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**FLIGHT PERFORMANCE MEASUREMENT TECHNIQUES DEVELOPMENT**
H. P. Washington 805-984-8653

The objective of this investigation is to develop new methods, techniques, sensors and analyses for evaluating the performance of modern flight test vehicles. The effort will be accomplished through in-house and contract support.

**W77-70155** **505-11-27**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**YF-17 AGILITY AND PERFORMANCE FLIGHT TEST PROGRAM**
R. G. Bryant 805-984-8401

This RTOP covers the flight test of the YF-17 Prototype aircraft for a short program that will permit the DFRC to continue to investigate several areas which can contribute to the basic research tasks in which NASA has a strong interest. The research objectives focus on these areas: (1) completion of previous research studies on maneuverability, which began during the JTF prototype test program; (2) afterbody pressure measurements; (3) piloting experience in the operation of an advanced high performance fighter aircraft; (4) pilot biomedical measurements at elevated load factors; and (5) measurement of vertical fin pressure and vibration levels.

**W77-70156** **505-11-28**
Langley Research Center, Langley Station, Va.
**NONAXISYMMETRIC NOZZLE TECHNOLOGY**
R. E. Bower 804-827-3285

The overall objective of this technology program is to evolve nonaxisymmetric nozzle technology to the point where it has an acceptable level of risk for transition into system developments of future advanced aircraft, such as the Advanced Tactical Fighter (ATF). A jointly funded NASA/military service program has been planned to accomplish this objective. This program is divided into two phases. The first phase consists of coordinated, but separate, agency studies of various nonaxisymmetric nozzle concepts installed on several different airframes. Airframes under primary consideration during this phase are the F-15 by NASA, the F-111 by USAF and the YF-17 by the USN. Included in this phase are wind tunnel tests, preliminary systems studies and DMS studies of each airframe as well as inputs from several other ongoing, related NASA/USAF/USN programs. The objective of this phase is to select one airframe/nonaxisymmetric nozzle concept, which could meet NASA/military, flight research objectives, for further evaluation, study and development. Following Phase I, selection of one aircraft/nonaxisymmetric nozzle concept, Phase II would begin. This phase would be jointly funded by the NASA and the military services and would consist of detailed system/design studies, structural/cooling studies, wind tunnel tests, subscale model cooling tests, and a full-scale engine/nozzle static test. These studies would lead to aircraft modification and a joint flight research program on this unique nozzle concept.

**W77-70157** **505-11-28**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**NONAXISYMMETRIC NOZZLE FLIGHT RESEARCH PROGRAM**
W. G. Schweikhard 805-984-8441

This RTOP proposes to 1) conduct a flight research program to assess the utility of an optimum nonaxisymmetric nozzle with thrust vectoring and reversing on a highly maneuverable aircraft, and 2) establish a base of data and analytical techniques with which to predict the performance of other aircraft and nozzle configurations.

**W77-70158** **505-11-28**
Lewis Research Center, Cleveland, Ohio.
**NON-AXISYMMETRIC NOZZLE TECHNOLOGY**
Ross Willoh 216-294-6624

The objective of this program is to provide the technology base for the design of non-axisymmetric exhaust nozzles for turbine engine applications. The high maneuverability requirements anticipated in future aircraft designs lead to requirements for non-axisymmetric nozzles capable of thrust vectoring. Experimen-

tal and analytical efforts will be undertaken to improve the technology base for the various technical disciplines associated with the design of non-axisymmetric exhaust systems. Principal areas of concern will include cooling, heat transfer and internal aerodynamics. The objectives will be accomplished through research subprograms including system studies, scale model rig tests and full-scale engine tests in PSL. Particular emphasis will be placed on seeking understanding and solutions to the complex cooling, structural and internal aerodynamic problems associated with nonaxisymmetric nozzles.

**W77-70159** **505-11-31**
Langley Research Center, Langley Station, Va.
**HYPERSONIC AIRCRAFT AERODYNAMIC TECHNOLOGY**
R. E. Bower 804-827-3285
(516-56-01; 505-04-31; 501-22-06)

The purpose of this work is to provide the technology for the design of efficient, practical hypersonic airbreathing aircraft. A number of aircraft systems are being studied. These include hypersonic transports, military strike and reconnaissance vehicles, hypersonic research airplanes, and the airbreathing launch vehicle. The airbreathing launch vehicle which is potentially capable of providing a truly low cost space logistics system can fill an expected need in the NASA/DOD program in the post 1990 time period. The hypersonic transport, with its long-range capability and cruise sonic boom levels that may be acceptable over populated areas, has the potential of providing a major step in air transportation in the latter part of the century. Airbreathing vehicle systems must fully exploit synergistic interactions between aerodynamics, propulsion, structures, trajectory selection, etc., to achieve maximum overall efficiency and operational flexibility. Detailed work on configuration concepts, reliable prediction techniques, full-scale Reynolds number effects, engine-airframe integration, etc., will be vigorously pursued to provide the technological base necessary. The technology for all three systems needs to be demonstrated in flight before commitment to mission hardware is made. The X-24C research aircraft concept resulting from the Joint USAF-NASA study completed in January 1975 will be used as a focal point in the technology development.

**W77-70160** **505-11-41**
Langley Research Center, Langley Station, Va.
**DOD SUPPORT - SPECIFIC REQUESTS**
R. E. Bower 804-827-3285

The broad objective is to provide technical assistance and consultative services to DOD for military programs which involve specific requests for NASA support. Current activity is focused in the areas of stall/spin; aerodynamic characteristics at subsonic, transonic, and supersonic speeds; flutter and aeroelasticity; structures; and landing loads. The approach will involve tests in applicable Langley facilities consistent with the availability of test time and the utilization need for the particular facilities requested. Analysis of test results will be performed and selected results will be documented. Consultation will include participation in pre-test conferences, technical evaluation boards, and technical coordination committees.

**W77-70161** **505-11-41**
Ames Research Center, Moffett Field, Calif.
**DOD ASSISTANCE**
L. Roberts 415-965-5848
(517-51-02; 505-11-14)

Technical assistance, consultive services, and facility support will be provided to the DOD in support of military aircraft and missile development programs. Included are research efforts to aid in assuring satisfactory aerodynamic and handling qualities of piloted aircraft in routine operational flight and in advanced weapon delivery tasks, and in assuring satisfactory flight path and attitude control of these aircraft in given automatic flight modes, such as radar-guided approaches and landings on an aircraft carrier. Included also are efforts to define and develop techniques for improvement of marginal or unsatisfactory characteristics of new airplane designs. Wind tunnels, flight simulators, and central computer facilities (360, 7600), together with applications of advanced control theory, will be employed as required. Specific weapon systems for which support is planned during FY 1976TQ and 1977 include the B-1, AV-8, XFV-12, HIMAT, YF-16, F-16 advanced fighter technology development, EA-6B and F-18 APC/ACLS development, and ACLS improvement for F-4, A-6E, and S-3A. Investigations of a missile recovery system and an underwater towing system are also included.

**W77-70162** **505-11-41**
Lewis Research Center, Cleveland, Ohio.
**OUTSIDE AGENCY SUPPORT AERONAUTICS TESTING**
D. N. Bowditch 216-433-4000

The objective is to support requests from the Department of Defense, Department of Transportation and other federal agencies outside of NASA for aerodynamic testing in the facilities of the Lewis Research Center.

**W77-70163** **505-15-31**
Ames Research Center, Moffett Field, Calif.
**DEVELOPMENT OF COMPUTATIONAL TECHNIQUES**
D. R. Chapman 415-965-5065
(505-06-12; 505-15-11; 514-52-02)

The objective is to invent new mathematical methods and to extend and improve existing methods for computer simulation of fluid flows. Various numerical methods will be analyzed, tested, and evaluated for reliability, accuracy, and efficiency using simple flows with known analytic solutions. Numerical analysis will be emphasized rather than the physical phenomenon. The ultimate objective, however, is the solution of the complete governing equations of fluid dynamics with the attendant boundary or initial conditions.

**W77-70164** **505-15-32**
Langley Research Center, Langley Station, Va.
**INSTITUTE FOR COMPUTER APPLICATIONS IN SCIENCE AND ENGINEERING (ICASE)**
J. E. Duberg 804-827-2664

This RTOP provides for the continuing operation of the Institute for Computer Applications in Science and Engineering (ICASE) located at the Langley Research Center, Hampton, Virginia. The Institute brings together experts from universities and industrial establishments to perform research in applied mathematics and computer science in conjunction with Langley research staff members. The major research areas include activities related to computational fluid dynamics, the efficient use of fourth generation computers, the development of numerical algorithms for scientific and engineering calculations, and large-scale engineering and scientific software systems. Additional research is carried out in a variety of areas also of interest to Langley Research Center. The Institute is operated under an agreement between the Langley Research Center and the Universities Space Research Association. This RTOP provides for a fee for the Association, salaries of a small permanent scientific staff, stipends for visiting university professors, post-doctoral fellowships, support for student assistants, and a small administrative staff. The Langley Research Center provides office space and some administrative and technical support.

**W77-70165** **505-15-35**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**NONLINEAR WAVE INTERACTIONS IN PLASMAS AND LASERS**
G. W. Lewicki 213-354-4530

The object of this RTOP is to develop a new applied mathematics for nonlinear differental systems, and to apply it to achieving a systematic understanding of new phenomena such as solitons in plasmas and laser media. The method being developed is especially applicable to coupled sets of nonlinear ordinary and partial differential equations, where results previously have been found by ad hoc methods. Examples are: (1) invariance transformations, (2) general similarity solutions, (3) characteristics, (4) integral conservation theorems, (5) discovery of nonlinear superposition principles, and (6) variational principles. Of these, (3), (4), and (6) are of direct applicability in writing programs for numerical computation. (5) and (6) are the most active current areas of research in applied mathematics, and progress by close interaction of computer simulation studies and analytical techniques. The method is based on the modern calculus of

exterior differential forms, and is especially appropriate for nonlinear equations such as occur in superconducting transmission lines, in nonlinear wave propagation in laser media, in plasmas, and in lattice structures. The most recent work under this task has been: (1) the discovery of transformations generating multiple 'soliton' solutions to nonlinear dispersive wave equations, and (2) the discovery of a 'prolongation structure' of potentials for solution of nonlinear equations. Work is in progress in applying the theory to the systematic discovery of conservation laws and variational principles. These are used in relaxation type computer calculations, and have previously been discovered only by ad hoc methods.

**W77-70166** **505-15-37**
Langley Research Center, Langley Station, Va.
**APPLIED MATHEMATICS AND COMPUTER SCIENCE**
J. E. Stitt 804-827-3745

This RTOP is for basic research in the disciplines of applied mathematics, numerical analysis, and computer science, with emphasis on the application of computers to aerospace problems. The objectives of this research are the development of mathematical and computer science theory and the development of more effective analytical and computational techniques for the solution of the types of aerospace research problems encountered at LaRC. In the 1976 transition period and in fiscal year 1977, the topics to be addressed are: (1) approximation theory and techniques, (2) mathematical optimization techniques, (3) the numerical solution of differential and algebraic systems, (4) statistical methods for cluster analysis, (5) interactive computer graphics, (6) symbolic and algebraic manipulation, (7) programing languages and methodology, (8) methods for multispectral reflectance estimates, and (9) applications of generalized functions. Most of the work covered by this RTOP will be performed in-house. Some contracted support is anticipated in the development of computer programs, comparative analyses, etc., and a number of grants or research contracts will be awarded and monitored in selected areas within the specialties of the LRC personnel.

## Aeronautics Systems Studies

**W77-70167** **791-40-13**
Ames Research Center, Moffett Field, Calif.
**CIVIL AIR TRANSPORTATION SYSTEM AND CONCEPT STUDIES**
W. H. Deckert 415-965-5887

The objective of this RTOP is to provide studies of future civil air transportation systems and concepts in order to identify promising aeronautical systems, determine optimum characteristics, and define technology requirements and costs associated with such systems. Studies will be conducted for a variety of air transportation systems emphasizing mid to short range. These studies will include market analyses, systems studies, operating cost analysis, and environmental impact analysis. This RTOP is responsive to the Program Objectives related to Civil Air Transportation Studies, Fuel Conservation in Aeronautics, and Systems Analysis Methodology and Support. Elements of this RTOP fall under the themes of either VTOL/Helicopters or R/STOL.

**W77-70168** **791-40-17**
Langley Research Center, Langley Station, Va.
**WORLD CIVIL AVIATION MARKET AND TECHNOLOGY OVERVIEW**
R. E. Bower 804-827-3838
(791-40-08)

The objective of this RTOP is to develop a capability to understand and monitor foreign competition in world civil aviation markets and provide for OAST a periodically updated report on status and trends in technology affecting relative competitive position of the U.S. We shall also seek to identify particular technology areas likely to have future impact on world civil aviation competition as an input to planning the NASA Aeronautics R&T program and for promoting a positive "Early Domestic Dissemination" program. Guidance for setting OAST R&T program objectives and targets based on worldwide economic implications will be provided. Also as required for major new areas, continued technology impact assessment of new technology on the national interest and public sector through predicted interaction with the economic, social, environmental, political and legal systems will be provided. The approach will be to formulate a useful analysis of foreign aviation industry, its accomplishments, competitive base, technology status, trends and potentials as well as promising long term market opportunities which may be important to the U.S. Indicators for comparison purposes will be developed and inputs to the OAST Aeronautics R&T program planning process will be made. The limited in-house world assessment and overview in aeronautics will be completed. This will be a precursor to a more comprehensive worldwide market assessment (contract study) which will be divided into tasks such as: present status, nearterm trends, long-term markets, markets in the developed and developing nations, and technology applications for NASA R&T. Also we will complete the present joint NASA/NSF Technology Impact Assessment Study.

**W77-70169** **791-40-21**
Ames Research Center, Moffett Field, Calif.
**MILITARY AIRCRAFT CONCEPT ANALYSIS AND METHODOLOGY DEVELOPMENT**
Richard H. Petersen 415-965-5881
(505-06-11)

The new objective of this RTOP is the development and application of methods to analyze the influence of advanced weapon systems on the design of military aircraft and missions. The purpose is to help the military define vehicles and technology to satisfy their future requirements and thus to provide direction for militarily oriented aeronautical research within NASA. The approach consists of applying analytical models of new weapon systems performance and defining associated conceptual aircraft at the early design stage to assess the effects of the new weapons on aircraft design, performance, and maneuverability. Military requests for concept design studies will not be supported beyond FY'76TQ and the computer programs to conduct these studies will be stored with existing documentation. Studies by the Research Aircraft Technology Office will be continued under other RTOPs.

**W77-70170** **791-40-27**
Ames Research Center, Moffett Field, Calif.
**AIRCRAFT CONCEPT ANALYSIS AND METHODS DEVELOPMENT**
Richard H. Petersen 415-965-5881
(505-06-11)

The objective of this work has been to develop and use an overall system synthesis capability to define the best airplane characteristics for various air transportation system concepts. Math models of the air vehicle elements were developed and verified by comparison with existing aircraft. Quick response studies were conducted to assess the impact of technology on the weight, cost and fuel conservation of new aircraft concepts. The new objective of this RTOP is to complete the studies committed to in FY'76 and place the ACSYNT computer program, developed under this RTOP, in a standby status. This will consist of storing the existing minimum documentation and check cases. Parts of the Level I and Level II aerodynamic analysis techniques will be used as a basis for aerodynamic performance prediction in the Aeronautics Division. Enhancement and development of these methods will be conducted under RTOP 505-06-11. All other aircraft design method technology development will be terminated.

**W77-70171** **791-40-31**
Langley Research Center, Langley Station, Va.
**STUDIES OF ALTERNATE AIRCRAFT FUELS AND GROUND SYSTEMS**
R. E. Bower 804-827-3285
(516-50-21)

The objectives are to ascertain through systems studies and detailed engineering studies the cost and technology requirements for and the overall impact of producing, delivering, storing, and

aircraft fueling of liquid hydrogen for use as an aviation fuel. The approach will be to conduct in-house and contracted engineering studies to determine the cost and thermal efficiency of producing liquid hydrogen and other synthetic aircraft fuels, and conduct systems studies to determine the most energy efficient and cost effective method for supplying liquid hydrogen to aircraft at the airport.

**W77-70172** **791-40-41**
Ames Research Center, Moffett Field, Calif.
**ANALYSIS OF FACTORS INFLUENCING THE GROWTH OF CIVIL AVIATION AND DEVELOPMENT OF A METHODOLOGY FOR ASSESSING THE BENEFITS OF AERONAUTICAL R&T**
C. A. Syvertson 415-965-5887

The objective of the work under this RTOP is to develop an understanding of the important factors influencing the growth of aviation and a methodology for assessing the potential benefits and costs associated with the introduction of improved aeronautical R&T on future civil aircraft. The tremendous growth of U.S. civil air transportation in the past has resulted from the operation of an aggressive, privately owned, government-regulated airline system which has been able to meet the desires of an expanding economy with new aircraft of ever-increasing productivity. However, the current decline in demand growth and the inability of the aircraft manufacturers to offer sufficiently superior new aircraft at effective prices has led to a period of increasing reliance on derivatives of existing equipment. In this period of relative stagnation, in the air transportation industry it is extremely important for the NASA aeronautics program to better understand the air transportation system and to develop a methodology for measuring the potential benefits and costs resulting from the introduction of improved technology on future aircraft. The development of this methodology will allow the NASA to better identify, quantify, and explain the rationale for investing in research with the greatest potential for application to improve the air transportation system.

**W77-70173** **791-40-42**
Ames Research Center, Moffett Field, Calif.
**INTEGRATED MULTI-MODAL TRANSPORTATION SYSTEM TECHNOLOGY**
J. Lloyd Jones 415-965-5566

The objectives are to enhance NASA's contribution in providing adequately for the nation's future transportation needs, including inter-modal systems and their energy and safety requirements; and to determine the possible effects on the time-frame and goals of aviation and air transportation R&T of promising future multi-modal transportation systems and corresponding urban structures. The approach will be based on innovative projections of possible future technologies, forecasts of multi-modal transportation system concepts, and estimates of social trends. Advanced air and ground transportation systems utilizing innovative multi-modal terminals will be designed conceptually with the consideration of community growth, economic patterns, environmental and social acceptance and political realities. These concepts will then be evaluated by more detailed engineering analysis and a fuller consideration of economics, and the advantages or disadvantages of the system.

**W77-70174** **791-40-44**
Goddard Space Flight Center, Greenbelt, Md.
**SYSTEMS ANALYSIS METHODOLOGY AND SUPPORT**
D. B. Wood 301-982-2330

This RTOP aims to provide an improved analytical basis for OAST management decisions on R&T program planning and selection to develop and exercise techniques by which modern systems, economic and decision analysis methods can be applied to the planning process, and to provide appropriate rationale for program evaluation.

## Aeronautics Systems Technology Programs

**W77-70175** **510-51-01**
Langley Research Center, Langley Station, Va.
**COMPOSITE MATERIALS APPLICATION TO THE C-130 CENTER WING STRUCTURE**
R. R. Heldenfels 804-827-2042
(505-02-41)

The objective of this program is to obtain longtime flight service performance of filamentary composite materials in the center wing box of C-130 aircraft. The objective will be achieved through a systematic program as follows: 1) conduct advanced development study to provide design allowables, manufacturing and process methods, and required analysis methods; 2) perform detailed design; 3) fabricate three composite-reinforced aluminum-alloy wing boxes, 4) perform ground test on one full-scale box (fatigue and strength), and 5) install wing boxes in two C-130 aircraft, and deliver aircraft to Air Force. The results of this flight service program will provide meaningful data on the performance of composite materials in a primary structure in the flight environment. Results will also be obtained on design, manufacturing and processing methods, nondestructive evaluation and field inspection procedures heretofore unavailable on large scale composite-reinforced primary aircraft structures. The program will provide confidence needed before commitments are made to future application in aircraft structures.

**W77-70176** **510-53-01**
Lewis Research Center, Cleveland, Ohio.
**MATERIALS FOR ADVANCED TURBINE ENGINES (MATE)**
N. T. Saunders 216-433-4000
(505-01-12)

The purpose of this program is to accelerate the application of advanced materials technologies to aircraft turbine engines in order to achieve improved engine performance benefits. The program involves the application of at least five materials technologies for engines planned for the 1980-85 timeframe. It covers the advanced development, rig testing, and engine testing necessary to demonstrate the potential of the new materials for use in future engines. The program is conducted through contracts with domestic engine manufacturers and their vendors. New materials that have shown laboratory feasibility in exploratory development programs have been selected for further development and evaluation under this program. Cost/benefit and risk analyses are conducted to help guide the selection of the best candidate materials. The selected materials are then scaled-up, manufactured into appropriate engine hardware, extensively evaluated to provide preliminary design data, and tested in both engine-simulation rigs and experimental engines to demonstrate their potential for future engine use.

**W77-70177** **510-54-01**
Langley Research Center, Langley Station, Va.
**INTEGRATED PROGRAMS FOR AEROSPACE-VEHICLE DESIGN (IPAD)**
R. R. Heldenfels 804-827-2042
(505-02-14; 743-01-01)

The objective is to reduce vehicle design cycle time by 50 percent and design costs by by 25 percent by 1980 through development of a computer-aided design system for industry. Statement of Work incorporates results of Boeing and General Dynamics IPAD feasibility studies, critiques of those studies, and a missile system design application study. Industry interface approach has been formulated and summarized in a Prospectus disseminated to industry. An advisory group to the prime contractor will be organized by the prime contractor and contain representatives from the aerospace industry. Industrial development will be undertaken with a prime contractor. The Boeing Commercial Airplane Company has been selected for negotiation. In-house work will be aimed at monitoring the contractor to ensure development of software which will improve the productivity of the U.S. aerospace industry.

**W77-70178** **510-55-01**
Lewis Research Center, Cleveland, Ohio.
**AEROELASTICITY OF TURBINE ENGINES**
M. J. Hartmann 216-433-4000

The overall objective of this area of research is to evolve improved empirical flutter boundary criteria and to obtain information concerning the factors that influence these criteria; and also, to provide, through analytical and experimental research, a more scientific basis for the reliable prediction and avoidance of instability regions. A program plan has been evolved by a joint NASA-LeRC/USAF-APL panel that was established in December 1973. The work outlined by this RTOP document is based on the deliberations of that panel and reflects the areas of responsibility recommended by the panel to LeRC. The LeRC program contains a number of related elements covering nonsteady aerodynamics, structural dynamics, coupling analyses, and experimental flutter boundary data collection and correlation. In-house theoretical and experimental studies will be complemented by contractual work to take advantage of special existing flutter research facilities and capabilities.

**W77-70179** **510-56-01**
Ames Research Center, Moffett Field, Calif.
**FIRE-RESISTANT MATERIALS ENGINEERING**
D. R. Chapman 415-965-5065
(505-01-31; 505-08-21)

The objectives are to provide the technology base required for the airframe manufacturers to make aircraft materials as fire-resistant as feasible in order to provide an increased probability of passenger and crew survivability in aircraft interior and exterior fires, and to accelerate the transfer of advanced materials technology to the aircraft manufacturers for possible application in the design of fire safe airframe structures and aircraft interiors. Tests will be conducted to assess the flammability and other properties of the state-of-the-art and improved materials. Fire-resistant material systems will be evaluated for ultimate application as lavatory wall panels and for additional design applications, such as ceiling and sidewall sandwich panels. Various thermoplastic polymers will be evaluated for aircraft interior applications which will result in significant reduction of fire and associated hazards. Fire-resistant materials including foams and fabrics will be evaluated as components of aircraft seats. This program will be conducted primarily with the three major airframe manufacturers and in cooperation with the Johnson Space Center.

**W77-70180** **510-56-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**FIRE RESISTANT MATERIALS ENGINEERING**
R. R. McDonald 213-354-6186

The objective of this RTOP is to reduce the fire hazard associated with aircraft systems. This objective will be accomplished by research on the modification of polymeric materials to develop additives, fillers and compositional changes which will reduce the flammability while also reducing the smoke and toxic gases generated, compared to conventional flame retardants that usually contain halogens, phosphorous or other elements that evolve toxic, smokey products.

**W77-70181** **510-56-04**
Lyndon B. Johnson Space Center, Houston, Tex.
**FIRE SYSTEMS TEST**
R. W. Bricker 713-483-3166

This effort defined in this RTOP consists of a continuation of work originally started in FY73 and maintained to FY76. It also provides for the additional tasks of testing components developed by Boeing Aircraft Corporation and the full scale tests under flight conditions at Douglas Aircraft Corporation of materials developed for NASA and of materials procured from other manufacturers of fire retardant materials. Included in the full scale tests will be a full scale cargo bay liner flammability test. The RTOP also provides for the continuation of the task for the delivery of technical data and reports which will expedite the evaluation and analyses of the various program segments.

**W77-70182** **511-52-01**
Lewis Research Center, Cleveland, Ohio.
**ENERGY EFFICIENT ENGINE -- PHASE I (SYSTEMS TECHNOLOGY)**
D. J. Poferl 216-433-4000
(511-54-01)

This is the first phase of a three-phase program culminating in the testing of an experimental turbofan engine designed with advanced technology elements capable of yielding at least a ten percent reduction in specific fuel consumption relative to current commercial high bypass engines. The objectives of this first phase (Systems Technology) are to define engine type and performance characteristics, establish a basis for advanced technology projections, and define engine component geometries for the selected energy efficient engine. Contracts will be awarded for engine design studies in order to provide refined definition of candidate advanced turbofan engines. From these studies, the energy efficient engine design characteristics will be chosen. Contracts will be awarded for two parallel technology and design efforts. Systems technology (analysis, design, and small-scale concept testing in areas such as materials, clearance control, and compressor aero) in areas not covered by related programs will be performed. Preliminary design will be done for all components. The compressor and high-pressure turbine will be designed in detail. Engine design studies will continue in order to continually factor component changes into the engine design and operational characteristics.

**W77-70183** **511-53-01**
Lewis Research Center, Cleveland, Ohio.
**QUIET, CLEAN GENERAL AVIATION TURBOFAN (QCGAT)**
G. K. Sievers 216-433-4000
(505-03-12)

An experimental program is planned to provide the technology for quiet, clean and economical general aviation turbofan engines. The program will utilize an existing general aviation turbine-driven gas generator core in an experimental, quiet, high bypass turbofan engine. The experimental engine will incorporate the latest quiet engine technology derived from the Quiet Engine Program, the Quiet, Clean Short-haul Experimental Engine Program and other related component technology programs. The approach to be used for noise reduction will be primarily directed toward the reduction of source noise by the use of such techniques as a high bypass ratio fan plus fan and turbine noise reduction techniques in preference to the use of extensive noise suppression systems. Three study contracts awarded to three engine manufacturers to provide NASA with information required to start an experimental engine program (QCGAT) have been completed. A single contractor is being competitively selected for the experimental program which consists of design, fabrication, assembly and ground tests of an experimental turbofan engine.

**W77-70184** **511-54-01**
Lewis Research Center, Cleveland, Ohio.
**ENGINE COMPONENT IMPROVEMENT PROGRAM**
Joseph A. Ziemianski 216-433-4000

The objectives of the Engine Component Improvement Program are to (1) develop components with improved performance which would reduce fuel consumption of current engines and be ready for introduction into new production of these engines in the 1980-1982 time period or sooner, and (2) provide additional technology which can be used to minimize the performance degradation of current and future engines. The program has been divided into two parts: Performance Improvement and Engine Diagnostics. The Performance Improvement part is aimed at developing fuel saving components for new production of the JT8D, JT9D and CF6. The primary elements of this part of the program are feasibility analysis, component rig/model tests, and full-scale engine tests. Components to be evaluated will include seals, clearance controls, exhaust nozzle mixers, and engine digital electronic control. The Engine Diagnostics part of the program will consist of analysis and test of the JT9D and CF6 engines to isolate and quantify the causes of engine performance degradation with time. This information will be used to improve current engines and aid in the design of future engines.

**W77-70185** **511-55-01**
Lewis Research Center, Cleveland, Ohio.
**STRATOSPHERIC CRUISE EMISSION REDUCTION**
R. A. Rudey 216-294-6856
(505-03-32; 743-03-21)

The objective is to establish and demonstrate the technology

necessary to reduce exhaust emissions from modern gas turbine aircraft engines to environmentally acceptable levels over the entire subsonic flight envelope with minimum adverse effects on performance, weight and complexity. Special emphasis will be placed on achieving extremely low (< 3g NO2/kg fuel burned) oxides of nitrogen (NOx) emissions at stratospheric cruise conditions. NOx emissions will be reduced by operating the combustion system at extremely lean fuel-air mixtures. Initially, fundamental in-house, grant, and contract studies will examine practical problems associated with this technique. Studies will be conducted to examine NOx production in lean combustion systems, flashback and autoignition limits, fuel preparation and stability augmentation techniques, and combustor constraints imposed by the engine. With the design information from the initial studies, combustor concepts will be integrated into engine system designs and assessed. Concepts which show potential for achieving program goals will be tested and screened. The most promising designs will be developed through component tests leading to an engine demonstration. If resultant optimized concepts cannot be incorporated into an existing engine, a preliminary engine design compatible with the combustion system will be developed.

**W77-70186** **511-56-01**
Lewis Research Center, Cleveland, Ohio.
**VARIABLE CYCLE ENGINE COMPONENT AND SYSTEMS TECHNOLOGY**
Albert G. Powers 216-433-4000
(743-03-11)

Advanced supersonic transport aircraft are required to operate over a wide variety of flight conditions. This creates conflicting requirements on the propulsion system which, in many cases, can be most effectively met by a Variable Cycle Engine (VCE). A VCE typically has 2 or more distinct operating modes, each tailored to provide optimum efficiency at one of the major flight conditions, e.g., takeoff, subsonic cruise and supersonic cruise. SCAR engine studies conducted under RTOP 743-03-41 have tentatively identified two VCE candidates of primary interest. These are the Pratt & Whitney Variable Stream Control Engine (VSCE) and the General Electric Double Bypass Engine (DBE). Both engines offer significant potential improvements over conventional engines in terms of both performance and environmental impact. Each depends, however, on the efficient functioning of novel and unique component types and on their compatibility with each other and with other engine subsystems, when integrated into the selected engine configurations. It is the objective of this RTOP to provide the component technology and component/engine integration data required in the most critical areas of both selected engines.

**W77-70187** **512-51-01**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**DIGITAL FLY-BY-WIRE FLIGHT EXPERIMENT**
Jarvis C. R. 805-258-3311
(512-51-02)

The overall objective of this effort with LaRC is to provide the technology necessary for the implementation of advanced reliable Digital Fly-By-Wire systems in future aircraft. Negotiations have been made with JSC to include as an additional objective; flight-test verification of certain Space Shuttle flight control system software, and redundancy management concepts. The program is to be carried out in accordance with the schedules and resources identified by the Digital Fly-By-Wire Project Plan (revised yearly). The Phase I flight-test program to establish Digital Fly-By-Wire systems Feasibility has been completed. In Phase II, a multichannel digital system is to be developed and flight tested in the F-8C aircraft. This will be a three-channel system utilizing redundancy management concepts developed for Space Shuttle application and providing the capability to evaluate, in flight, advanced control laws being developed by LaRC.

**W77-70188** **512-51-02**
Langley Research Center, Langley Station, Va.
**DIGITAL FLY-BY-WIRE FLIGHT EXPERIMENT**
J. E. Stitt 804-827-3745
(512-51-01; 505-07-31)

The overall objective of this joint effort with DFRC is to provide the technology necessary for the implementation of advanced reliable Digital Fly-by-Wire systems in future aircraft. The program has two phases. The initial phase demonstrated the feasibility using existing Apollo derived hardware. For phase II, a Triplex digital system is being developed for laboratory and flight testing to provide a design base for this technology. DFRC has the overall project management responsibility including the system design, fabrication, checkout and flight testing. LaRC is responsible for the research and development of advanced control law (ACL) concepts to be implemented during the flight test program. Three ACL's will be implemented - control configured vehicle, adaptive and learning/failure management. After the ACL concepts have been developed by LaRC, DFRC will initiate the task of specification development and in conjunction with LaRC, the ACL's will be validated through laboratory simulations and Iron-Bird prior to flight test demonstrations. Additional details are outlined in the current Project Plan dated June 1975.

**W77-70189** **512-52-01**
Ames Research Center, Moffett Field, Calif.
**GENERAL AVIATION - ADVANCED AVIONICS SYSTEM**
C. T. Snyder 415-965-5427

The program objective is to provide the information required for the design of a reliable low-cost avionics system applicable to general aviation which will enhance the safety and utility of this mode of transportation. Data will be accumulated upon which industry can base the design of a 'reasonably priced' system having the 'capability' required by general aviation in and beyond the 1980's. The approach is to synthesize various subsystem concepts and conduct supporting studies of the projected microelectronic and fluidic technology, aircraft design and air traffic control environment of the 1980's to formulate a system definition which can be scrutinized against requirements and cost benefit criteria to formulate final specifications and designs. The system design will be verified in simulations and flight tests with active participation of the FAA and the aviation industry. This is a joint program between ARC and LaRC. The lead center is ARC who, in addition to component and subsystems development, is responsible for the overall final system design, fabrication, simulations and flight tests. LaRC is responsible for the development of fluidic components and some avionic subsystems with emphasis directed towards the light aircraft end of the general aviation spectrum.

**W77-70190** **512-52-02**
Langley Research Center, Langley Station, Va.
**GENERAL AVIATION ADVANCED AVIONICS**
J. E. Stitt 804-827-3745
(505-07-12; 505-07-22; 513-05-51)

The objective of this project is to design and demonstrate integrated avionics systems which will enhance the safety, reliability, and utility of future general aviation aircraft. The specific portion of this program performed by LaRC is directed toward the application of advanced technology to the light-plane portion of the general aviation spectrum, primarily in the instrumentation, control, and safety-related areas. Fluidic, micro-processor, and micro-electronic technology will be examined for application to navigation, guidance, control, and display functions. Fluidic components, sensors, and systems will be developed and evaluated through simulation and flight test, with initial cost, maintenance, and reliability as primary drivers. Examples are a gyroless autopilot with the potential for extremely high reliability and low maintenance, and ram-air powered, limited-authority fluidic controls which operate independently of the aircraft primary control systems. Advanced electronics technology will be applied to navigation and guidance functions including the examination of IMC display aids, and safety-related areas such as stall-onset warning and control. Also, the role of advanced systems such as NAVSTAR/GPS in general aviation will be examined through studies and conceptual designs.

**W77-70191** **513-50-50**
Langley Research Center, Langley Station, Va.
**TRAVELER ACCEPTANCE - LOW DENSITY SHORT-HAUL SYSTEMS**

R. E. Bower 804-827-3285
(504-09-21)

The objective is to identify, study in detail, and model those factors influencing acceptance and use of aircraft as the preferred mode of travel by the public in the low- to medium-density short-haul market. Appropriate information will be compiled through literature search, traveler questionnaires, and measurements aboard low- to medium-density, short-haul airline systems. Limited information will also be obtained concerning competing modes of transportation which could influence choice of travel mode. The data will be analyzed and mathematically modeled. Some existing types of aircraft used in low-density, short-haul service will be evaluated using this model. The majority of effort will be carried out under grant.

**W77-70192** **513-50-51**
Langley Research Center, Langley Station, Va.
**VLF NAVIGATION SYSTEMS TECHNOLOGY STUDIES (GENERAL AVIATION)**
E. M. Bracalente 804-827-3631
(505-07-12)

The objective of this work is to investigate VLF navigation techniques and to develop promising approaches for enroute and terminal area navigation. Systems such as Omega can provide large geographic coverage with a limited number of ground stations, and are relatively unaffected by altitude or terrain. Characteristics such as these are highly desirable for general aviation aircraft, where direct terminal-to-terminal routes at relatively low altitudes are required. The application of VLF navigation to civil aviation will also enhance air safety by reducing pilot workload required by navigating within a network of approximately 1,000 VOR stations. Work is being conducted in two areas. The first area consists of the measurement and analysis of errors due to propagation anomalies and atmospheric noise. The second area consists of the development and evaluation of Omega avionics, including both differential and composite Omega configurations.

**W77-70193** **513-50-53**
Ames Research Center, Moffett Field, Calif.
**ANALYSIS OF THE OPERATIONAL COMPATIBILITY OF FUTURE CIVIL AIR TRANSPORTATION CONCEPTS**
W. H. Deckert 415-965-5887

The objective of this RTOP is to identify the cost and operating system implications of new commuter aircraft designed with various degrees of advanced technology. The design emphasis is to provide aircraft with low initial and operating costs, improved safety, dependability, and environmental compatibility. The operating system analysis will consider the impact of new low cost design characteristics on the short-haul airport system, regional travel patterns, viability of operation, and benefits to the public. These studies will be performed both in-house and under contract. Close coordination will be maintained with the Department of Transportation during these studies.

**W77-70194** **513-50-54**
Ames Research Center, Moffett Field, Calif.
**FEASIBILITY AND VALIDATION OF LOW COST MICROWAVE LANDING SYSTEM AVIONICS**
C. T. Snyder 415-965-5488
(513-53-02; 513-53-03; 513-52-01)

The overall objective is to support the FAA in implementing the National Microwave Landing System (MLS) Program by validating the feasibility of low cost airborne MLS avionics. Specific objectives include establishing the operational/functional requirements and specifications for a low cost MLS receiver; designing, constructing, and testing selected subassemblies that have the greatest potential for reducing receiver cost; assessing low cost receiver performance by integrating the individual subassemblies into a functional receiver; flight validating the avionics feasibility model performance for application to low density STOL and small community business and general aviation operations; and producing a detailed final report for distribution to the FAA and avionics/MLS manufacturers. The basic approach is to accurately define the required low cost MLS receiver performance specifications, identify the cost critical receiver subassemblies, design and construct brassboard models of those selected subassemblies with the prime emphasis on reducing cost and establishing a design-to-cost figure, integrate the subassemblies into a feasibility model MLS receiver and perform a flight test validation of the receiver. Refined cost projections will be obtained after hardware optimizations are made. Optimizations will assume volume fabrication/production techniques and a quantity standard. Cost reduction of operational MLS avionics developed will be the primary measure of program effectiveness.

**W77-70195** **513-50-55**
Ames Research Center, Moffett Field, Calif.
**SIMULATION METHODS FOR THE CERTIFICATION AND FAILURE EFFECTS ANALYSIS OF DIGITAL AVIONICS AND FLIGHT CONTROL SYSTEMS**
C. T. Snyder 415-965-6301

This RTOP proposes to indentify, evaluate and develop simulation methods and supporting criteria for the certification and failure effects analysis of digital avionics and flight control systems with an emphasis on the role of piloted systems/mission simulation technology. In cooperation with the FAA and Industry, Government and Industry needs and interests will be identified through workshops, symposiums, and working sessions. Inhouse and contract studies will be conducted and assessment of the following areas will be made: (a) industry certification methods and rationale, (b) the role of simulation in the certification of aircraft operating systems, (c) methods for evaluating/validating certification methods, (d) methods for the certification and control of software, and (e) methods for predicting and validating system (hardware and software) reliability. Real time simulations will be conducted to investigate and validate the most promising methods and assess the impact of failures on safety of flight margins using representative classes of flight hardware and software (R-NAV, digital flight controls, active controls, etc.). Assessments, as appropiate, will be made regarding alternative analytical and flight methods.

**W77-70196** **513-52-01**
Langley Research Center, Langley Station, Va.
**TERMINAL CONFIGURED VEHICLE PROGRAM**
J. E. Stitt 804-827-3745
(505-07-31)

The Terminal Configured Vehicle (TCV) Program is an advanced technology activity focused on Conventional Take-off and Landing (CTOL) Transport Aircraft that will be operating in reduced weather minima in the future high-density terminal areas equipped with new landing systems, navigational aids, and increased surveillance and automation under development by DOT/FAA. The broad objectives of the Program are to provide improvements in the airborne systems (avionics and air vehicle) and operational flight procedures for reducing approach and landing accidents, reducing weather minima, increasing air traffic controller productivity and airport and airway capacity, saving fuel by more efficient terminal area operations, and reducing community noise by operational procedures. This involves research analyses, simulations, and flight studies. A modified Boeing 737 airplane, (Research Support Flight System, RSFS), equipped with highly flexible display and control equipment being made available by DOT/FAA, will be used to study operations in simulated future terminal area environments.

**W77-70197** **513-53-02**
Ames Research Center, Moffett Field, Calif.
**MICROWAVE LANDING SYSTEM VALIDATION FOR STOL AIRCRAFT APPLICATIONS**
C. T. Snyder 415-965-5567
(513-53-01; 513-50-54)

The overall objective is to assist the FAA in developing the Microwave Landing System (MLS). Specific objectives include the evaluation of the prototype MLS for STOL operations; support and participation in the Joint DOT/DOD/NASA prototype MLS tests; and, assistance to the FAA in the development of the limited production MLS specifications, including investigations of MLS problem areas. The basic approach is to utilize the Ames MLS related analysis, simulation, and flight test capabilities/facilities to conduct a Joint DOT/DOD/NASA evaluation of a

prototype MLS installed at Crows Landing. Static and dynamic MLS tests will be conducted to determine the suitability and adaptability of the prototype MLS to a broad spectrum of civil and military operations.

**W77-70198** **513-53-03**
Ames Research Center, Moffett Field, Calif.
**STOL OPERATING SYSTEMS EXPERIMENTS USING MODELS AND THE CIVIL/MILITARY MICROWAVE LANDING SYSTEM (MLS)**
C. T. Snyder 415-965-5424
(513-53-01)

Experiments will be conducted on navigation, guidance, control, and flight management systems for STOL aircraft using advanced airborne avionics and a Microwave Landing System. The results will be used to evaluate system concepts and define design criteria and operational procedures for STOL aircraft. Investigations will be conducted encompassing analysis, simulation, flight experiments, and supporting studies. These investigations will emphasize the terminal area navigation, guidance, control and flight management problems which must be solved to take maximum advantage of STOL capabilities for making steep ascents and descents, tight turns, and slow speed approaches and landings. The flight experiments will be conducted using a flexible research avionics system, referred to as STOLAND, in conjunction with appropriate STOL aircraft. The complete research system comprises STOL aircraft, avionics system, instrumentation, and the following navigation aids: VOR/DME, TACAN, and a microwave landing guidance system to be provided by the FAA.

**W77-70199** **513-53-05**
Ames Research Center, Moffett Field, Calif.
**INVESTIGATION OF THE USE OF STRAPDOWN INERTIAL SENSOR UNITS FOR THE INTEGRATION OF FLIGHT CONTROL, GUIDANCE AND NAVIGATION FUNCTIONS.**
C. T. Snyder 415-965-5983

The objective is to identify, demonstrate and evaluate promising low cost, high reliability, strapdown technology applicable to short-haul air transportation with an emphasis on (a) use and performance of laser gyro strapdown technology for integrated flight control in an actual flight environment, and (b) use and performance of advanced software redundancy management techniques for improving reliability of integrated strapdown systems. In-house and directed studies will be utilized to establish (a) requirements for integrated strapdown flight control for short-haul aircraft, (b) promising integrated flight control systems configurations, (c) limitations and performance criteria for integrated flight control strapdown concepts, and (d) promising reliability enhancement concepts based on software redundancy management strategies. Analytical, simulation, moving base hardware/software systems simulations and flight experiments data will be obtained to assess and demonstrate potential concepts and configurations. Initially, experimental data will be obtained using the ARC-CSDL-SIRU system, but the primary empahsis of this program will be the specification, construction, demonstration and assessment of laser gyro strapdown integrated flight control technology for short-haul using a TETRAD system built under contract by Honeywell, interfaced with STOLAND, and test flown in controlled short-haul terminal area approach and landing experiments.

**W77-70200** **513-53-06**
Ames Research Center, Moffett Field, Calif.
**TERMINAL AREA EFFECTIVENESS PROGRAM - OPTIMIZATION OF FLIGHT PROCEDURES OF SHORT-HAUL TRANSPORT AIRCRAFT**
C. T. Snyder 415-965-5450

The overall objective of this program is to investigate the effects of advanced airborne navigation and guidance concepts, applicable to short-haul aircraft, on the efficiency of operations in the terminal area. The criteria for measuring terminal area efficiency include such factors as fuel usage, noise impact, terminal area capacity, compatibility with the air traffic control system, and controller and pilot acceptance. Simulation experiments and studies will be conducted to determine the effectiveness of candidate operational procedures for fuel conservation, noise reduction and capacity expansion. These studies will form the basis for selecting the best technical alternatives and tradeoffs for increasing operational effectiveness of short-haul aircraft. An existing simulation facility used to investigate the efficiency of STOL operations in the terminal area will be expanded to provide a more realistic environment for evaluating terminal area procedures. Enhancements of the facility include improved partitioning of laboratory space and upgrading of displays and software. In addition, communications and data links will be installed between the Terminal Area Simulation Facility at Ames and the Crows Landing Experiments Site.

**W77-70201** **513-54-01**
Ames Research Center, Moffett Field, Calif.
**VTOL OPERATING SYSTEMS EXPERIMENTS**
C. T. Snyder 415-965-5430
(513-53-01; 513-53-03)

The objective is to develop a data base for use in establishing navigation, guidance, and control system concepts, design criteria, and operational procedures for VTOL aircraft. This technology base will aid the development of efficient, economical VTOL short-haul operations with minimum adverse environmental impact. The objective also includes a research and technology program to support Army requirements for assuring a VTOL operational capability into a wide variety of landing sites, under reduced visibility conditions. The approach will utilize: analytical studies, piloted closed-loop simulations, and flight experiments. Analytical studies will be carried out in-house and under contract. Piloted simulation studies will be accomplished at Ames prior to flight tests. Flight experiments will be carried out in the Tilt Rotor Research Aircraft (XV-15) using the V/STOLAND avionics system. Two VSTOLAND systems are being procured and will be installed alternately in the S-19 dual-purpose (UH-1H and XV-15) fixed-base simulator cab and in the UH-1H and XV-15 aircraft. The simulator installation will be used for piloted simulation studies and computer software development for the NASA and Army programs. The navigation, guidance and display concepts being developed for use in the XV-15 operating systems flight experiments will first be evaluated on the UH-1H/VSTOLAND system. The XV-15/VSTOLAND will be used to investigate alternative functional configurations, time constrained flight paths, and omnidirectional approaches.

**W77-70202** **513-54-02**
Langley Research Center, Langley Station, Va.
**ROTARY WING VTOL OPERATING SYSTEMS EXPERIMENTS**
J. E. Stitt 804-827-3745
(505-10-23; 505-07-41)

The program will encompass the investigation of operating systems and piloting techniques for operations from downtown vertiports under all-weather conditions. Terminal air traffic procedures, airspace requirements, and avionics system requirements will be defined. Flight vehicles and simulation facilities equipped with electronic display systems and advanced control concepts will be used to define the degree of automation required in the aircraft control system and in the guidance, display, and communication systems onboard the aircraft for VTOL terminal-area operations. Operating procedures and piloting techniques for curved, decelerating approach trajectories will be explored for application to steep-gradient operations into congested areas. As part of the joint NASA/Army program in which a CH-47 is being provided by the Army, studies will be made of pilot cueing requirements for improved handling qualities, warning for critical envelope limits and for aiding the pilot in interfacing with the automated or partially automated control systems.

**W77-70203** **514-50-01**
Ames Research Center, Moffett Field, Calif.
**ADVANCED V/STOL AIRCRAFT DESIGN AND APPLICATION STUDIES**
W. H. Deckert 415-965-5887
(505-10-27)

The objective of this effort is to investigate advances in V/STOL aircraft technology which offer unique performance and

operational advantages for civil and military application. A design integration study will be performed to provide guidance for developing a program that incorporates advances hingeless tilt rotor technology, composite rotor blades, and fly-by-wire control systems on the XV-15 research aircraft. The design integration study will identify the major design problems, provide design solutions, and estimate air vehicle performance, handling qualities, flight envelope limits, and program tasks and cost. The study will also define an appropriate fullscale wind tunnel testing program for evaluating this advanced tilt rotor technology.

**W77-70204** **514-50-02**
Ames Research Center, Moffett Field, Calif.
**LIFT-CRUISE FAN SYSTEM TECHNOLOGY PROGRAM-DESIGN STUDIES**
W. H. Deckert 415-965-5903
(505-10-35)

This RTOP is to cover Technology Programs and a portion of the Phase I, Aircraft Preliminary Design for the NASA/Navy Lift/Cruise Fan Research and Technology Aircraft. The supporting technology includes concept design studies and wind tunnel tests. The studies will include refinements to the conceptual designs of both the propulsion system and the airframes. These studies will provide information and data on which program costs can be estimated and risk can be assessed for both propulsion systems. The Phase I, Aircraft Preliminary Design is in preparation for a New Start in FY 1978 and is funded by this RTOP and RTOP 505-10-35. The overall Program cost for supporting technology and research aircraft procurements are cofunded with U.S. Navy.

**W77-70205** **514-52-01**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**WAKE VORTEX MINIMIZATION FLIGHT RESEARCH**
M. R. Barber 805-258-3311
(505-06-22; 505-08-22)

This RTOP covers continuing DFRC activities related to fullscale flight-test evaluations of various aerodynamic wake vortex alleviation devices. These devices have been, and/or, are being developed in ground facility tests under the related RTOP (505-06-22). The approach taken is that of flying the devices on actual transport aircraft (e.g., 747's, DC-10's, L-1011's etc.). Comparisons of the vortex characteristics with and without the devices are made by probing the aircraft's wake with specially instrumented probe aircraft (e.g., DFRC's T-37, ARC's Lear Jet, and the FAA's DC-9). To facilitate wake probing specialized vortex visualization systems are being used and developed (development is under the related RTOP (505-08-22).

**W77-70206** **514-52-01**
Langley Research Center, Langley Station, Va.
**WAKE VORTEX MINIMIZATION FLIGHT RESEARCH**
R. E. Bower 804-827-3285

The objective is to develop and demonstrate wake vortex minimization methods and devices acceptable for routine aircraft operations. Laboratory and flight tests have established the feasibility of modifying the trailing vortex system of an aircraft by aerodynamic means. Laboratory testing will continue to develop alleviation means that will allow safe and economic operation of aircraft with separation distances of 2 nautical miles. Flight evaluations will be conducted as required to demonstrate the effectiveness and operational suitability of the alleviation methods and devices.

**W77-70207** **514-52-01**
Ames Research Center, Moffett Field, Calif.
**WAKE VORTEX MINIMIZATION FLIGHT RESEARCH**
C. T. Snyder 415-965-5567
(505-08-22)

Aerodynamic solutions for minimizing aircraft trailing vortices will be investigated, for near and far term applications. Investigations will be made to determine: (1) the fundamental mechanisms involved in vortex generation and decay, (2) the components of vortex velocity, turbulence, and the rolling moment on a following aircraft up to large distances behind the aircraft for various conditions of angle of attack, flap deflection, stabilizer incidence, etc., and (3) vortex dissipation resulting from variations in span loading and turbulence at the generating aircraft. Both theoretical studies and experimental investigations utilizing wind tunnels and water tow facilities will be made.

**W77-70208** **514-52-02**
Ames Research Center, Moffett Field, Calif.
**NUMERICAL SIMULATION OF VORTEX WAKES**
D. R. Chapman 415-965-5065
(505-06-12; 505-15-31)

The objective is to obtain computer simulations of the vortex wake behind a large airplane in the takeoff and landing condition in order to test concepts for alleviating the problem. The three-dimensional Navier-Stokes equations with an eddy viscosity for the turbulence are solved numerically to determine the time history of the vortical turbulence caused by the landing gear, flaps, nacelles, and other protuberances. Two approaches will be taken, one in a Lagrangian vortex-tracing frame and the other in an Eulerian grid. Initially, simple vortex interactions will be studied to test the codes and to verify the validity of the approaches with each other and with experiment. Eventually, the codes will be used to study the sensitivity of the wake flow to changes in aircraft configuration, flap deflection, and wing loading.

**W77-70209** **514-53-01**
Langley Research Center, Langley Station, Va.
**ROTOR SYSTEMS FOR ROTOR SYSTEMS RESEARCH AIRCRAFT**
R. E. Bower 804-827-3285

The primary objective of this systems technology program is to expand rotor systems research to exploit the potential for significantly improved helicopters in the broad areas of performance, efficiency, noise, and dynamics, through the acquisition and flight evaluation of three advanced-rotor concepts. A technology program for hardware development and flight experiments will be defined for testing of current and advanced-technology rotor systems through a broader flight envelope to define and document technological advancements for rotors and rotorcraft. Through a series of advanced systems design study contracts initiated in FY 1975 and FY 1976, preliminary designs of several new rotor concepts are being described and definitive program plans are being developed in order to establish both technical and budgetary data necessary for initiating major rotor systems design and fabrication contracts for RSRA research rotors. Parallel efforts will be continued to provide the design verification data required for both the Variable Geometry Rotor and the Composite Structures Rotor.

**W77-70210** **514-54-21**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**F-15 AIRFRAME/PROPULSION SYSTEM INTERACTION EXPERIMENT**
J. L. Kolf 805-258-3311

The objectives of this effort are: (1) to determine full-scale F-15 airframe/propulsion system interference drag for correlation with scale model wind-tunnel test data, (2) to assess F-15 engine/inlet compatibility for correlation with wind-tunnel data to improve predictive techniques, (3) to evaluate an in-flight measurement technique, (4) to assess F-15 high alpha and agility flight characteristics for correlation with wind-tunnel tests and 3/8-scale model flight data, and (5) to support the USAF in determining the acceptability of F-15 product improvement items. Two F-15 aircraft are being flown at DFRC to obtain the necessary flight-test data to correlate with the wind-tunnel and analytical studies being performed at ARC, LaRC and LaRC. A steering group comprising members from each of these Centers as well as NASA Headquarters and USAF will provide the coordination of the wind-tunnel, analytical, and flight-test studies to insure optimum results from the Joint effort.

**W77-70211** **514-54-21**
Lewis Research Center, Cleveland, Ohio.
**PROPULSION AIRFRAME INTERACTIONS**
R. E. Coltrin 216-433-4000

To assess and improve test techniques and methodologies used to predict airframe-engine compatibility for highly maneuver-

able and cruise aircraft. The propulsion airframe interaction data banks obtained during the development of the F-15 and B-1 aircraft, supplemented by any extreme maneuver engine surge data obtained from the NASA-DFRC F-15 flight research investigation, will be the basis for these studies. These efforts will be accomplished through contracts with the contractors involved with the development of the F-15 and B-1 propulsion systems. Engine airflow calibration will be provided for the NASA-DFRC flight program.

**W77-70212** **514-55-01**
Langley Research Center, Langley Station, Va.
**LAMINAR FLOW CONTROL TECHNOLOGY**
H. T. Wright 804-827-3265

The broad objective of this Laminar-Flow Control (LFC) element of the NASA Aircraft Energy Efficiency (ACEE) Program is to demonstrate that predicted reductions in fuel consumption are attainable for new-design commercial transports through the application of laminar-flow control and to validate acceptable economics in the manufacture and safe commercial operation of LFC airplanes. The technology developed will be applicable to military transports. The LFC element of ACEE consists of three phases; (1) precursor activities and systems definition, (2) systems development, and (3) flight validation. The Phase I activities which will be accomplished in the fiscal years 1976 through 1978 are covered by this RTOP. These include design and testing of a supercritical airfoil compatible with LFC requirements, alleviation of the insect contamination problem, improvement of design tools and LFC systems definition.

**W77-70213** **515-51-11**
Ames Research Center, Moffett Field, Calif.
**HUMAN FACTORS IN AVIATION SAFETY**
H. P. Klein 415-965-5094
(504-09-32; 505-08-23)

The objectives are: (1) to provide information regarding factors in the aviation system which cause or contribute to the occurrence of human and other errors in aviation operations; (2) to evaluate the potential dangers posed by these factors in aviation operations, (3) to examine ways of eliminating such factors from the aviation system, or of minimizing their potentially harmful effects; and (4) to reduce the incidence of aviation accidents caused by or attributed to human errors. The approach used will include: (1) descriptive and analytic studies of occurrences, incidents and accidents to determine system and other factors which are associated with human errors in aviation operations; (2) full-mission simulation studies to evaluate the ways in which these factors influence human performance; (3) laboratory research as required to supplement simulation experiments of effects of threat factors; (4) evaluation in simulation or flight research of candidate solutions designed to eliminate or minimize the decremental effects of these factors; and (5) collaboration with government and industry groups in implementing promising solutions designed to reduce the number and seriousness of human errors in the aviation system.

**W77-70214** **516-50-10**
Ames Research Center, Moffett Field, Calif.
**OBLIQUE WING AIRCRAFT SYSTEM STUDIES**
Richard H. Peterson 415-965-5881
(505-06-11)

The objective of this program was to support the Dryden Flight Research Center flight test programs of oblique-winged aircraft. Responsibilities of Ames Research Center were to conduct contract and in-house analyses in the area of overall aircraft performance. Studies were conducted to define the potential advantages of oblique-winged vehicles for civil as well as military systems. No new studies or extensions will be initiated in FY-76TQ or FY-77. ARC will be responsible under ARC RTOP 505-11-11 for providing wing tunnel support, theoretical aerodynamic estimates, aeroelastic analysis in design and simulation of the DFRC oblique winged flight projects.

**W77-70215** **516-50-11**
Ames Research Center, Moffett Field, Calif.
**SHORT-MEDIUM RANGE ADVANCED TECHNOLOGY AIRCRAFT DESIGN STUDIES**
W. H. Deckert 415-965-5887

The objective of this work is to help develop a sound technological base for future decisions relating to the design, development, and operation of commercial air transportation systems. This objective will be achieved through studies that examine the relationships between aircraft technology, airline economics and markets, and environmental constraints. These studies will be done in sufficient detail to provide a realistic assessment of the critical technical problems regarding transport aircraft design, development and operations and their development and operational costs. Results will be used to help define the future direction of productive technical (and system related) activity for air transportation systems. During the next year these studies will concentrate on determining the potential for advanced turboprop powered aircraft and identifying the most promising application of other technologies for improved short-haul aircraft energy efficiency. These investigations will be performed in-house and under contract.

**W77-70216** **516-50-20**
Langley Research Center, Langley Station, Va.
**ADVANCED TRANSPORT SYSTEMS TECHNOLOGY STUDIES**
R. E. Bower 804-827-3285
(791-40-08)

The objectives are to perform systems and design integration studies for CTOL commercial transports in order to: (1) identify and quantitatively evaluate technology advances that will improve aircraft economics, fuel consumption, noise, emissions and terminal-area congestion; (2) determine the technical and economic feasibility of very large cargo concept; and (3) provide design concepts for improved transport aircraft. In-house studies supplemented by contractor studies in critical areas will be performed for aircraft systems. Contractor capabilities will also be utilized to upgrade existing in-house vehicle design computer software.

**W77-70217** **516-50-21**
Langley Research Center, Langley Station, Va.
**LIQUID HYDROGEN-FUELED AIRCRAFT TECHNOLOGY**
R. E. Bower 804-827-3285
(719-40-11)

The objectives are to provide a technology base in materials, structures, configurations, and fuel systems to establish the feasibility and payoffs of liquid hydrogen fueled aircraft, and to determine the hazards and preventative measures which will permit a high degree of safety for hydrogen-fueled aircraft. The approach is to perform in-house and contracted studies to determine the performance potentials of LH2 aircraft. Perform a contracted engineering analysis to determine the technology requirements of an LH2 system optimized for total system performance. Conduct contracted R&T programs on insulations and fuel delivery system components. Under contract, assess the hazards of the use of LH2 as an aircraft fuel, in the aircraft, at the airport, and in the upper atmosphere. Conduct in-house analytical studies to assess the performance potential of synthetic aircraft fuels other than hydrogen.

**W77-70218** **516-51-01**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**YF-12 FLIGHT EXPERIMENTS**
Berwin Kock 805-258-3311
(743-01-23; 743-05-22; 743-01-21; 743-01-22)

The YF-12 type airplanes are the only airplanes in the free world which are capable of sustained Mach 3 flight. Major areas of research include the examination of the hot, flexible structure; dynamic inlet behavior; airframe/propulsion interaction; and general problems related to high speed and high altitude flight. Fundamental data are obtained in boundary layer characteristics, unsteady aerodynamics, dynamic structural behavior and other basic technology areas. The flight data are used to validate current analytical and experimental predictive techniques for the design of high speed aircraft. The airplanes are used to support numerous Supersonic Cruise Aircraft Research Projects. Several carry along

type experiments that require the high altitude and/or high speed capabilities of the YF-12 are planned for the aircraft.

**W77-70219** **516-51-02**
Ames Research Center, Moffett Field, Calif.
**YF-12 DISCIPLINARY RESEARCH**
Richard H. Petersen 415-965-6266
(505-11-21)

The unique performance capabilities of the YF-12 airplane provide an opportunity to obtain heretofore unavailable flight data and to conduct flight experiments that cannot be duplicated in ground based facilities. Comprehensive wind tunnel tests have been conducted to document the aerodynamic characteristics of the inlet system and these results will be compared to comparable flight data obtained this coming year. In addition, wind tunnel test and computational support of the planned flight test program to improve the performance of the test aircraft will be provided. The general scope of the effort covered by this RTOP is being changed from direct participation to one of general support of the program elements through consultation with the members of the staff possessing the desired expertise and the use of our computational and experimental facilities.

**W77-70220** **516-51-02**
Langley Research Center, Langley Station, Va.
**YF-12 DISCIPLINARY RESEARCH**
R. E. Bower 804-827-3285
(766-72-02; 766-72-02; 766-72-02)

The objectives are to evaluate analytical techniques for predicting boundary layer transition, heat transfer, and skin friction; to provide the basis for improved design prediction techniques; to define and provide solutions for unknown problems in flight, and to evaluate the application of experimental wind tunnel results to flight conditions. The approach will be to conduct pertinent ground-based analyses and wind-tunnel tests on a boundary layer test component (hollow cylinder 10 ft. long and 1.5 ft. in diameter) that will be flight tested on the YF-12 aircraft; analyze and correlate these data with those from flight tests on the same component.

**W77-70221** **516-53-01**
Langley Research Center, Langley Station, Va
**ENERGY EFFICIENT TRANSPORT FOR THE AIRCRAFT ENERGY EFFICIENCY PROGRAM (ACEE)**
H. T. Wright 804-827-3265
(505-02-22; 512-53-01)

This effort proposes to expedite industry acceptance and application of advanced aerodynamics and active controls in an integrated manner to achieve significant energy savings and economic benefits. Existing data bases will be expeditiously expanded and validated using in-house and contracted experimental and analytical efforts in the areas of supercritical aerodynamics, high-lift devices, propulsion/airframe integration, wing/empennage/active controls integration and reliable, maintainable flight control. Long-term emphasis will be given to those technology elements assessed as the most promising for application to wide-body derivative and/or new transport aircraft.

**W77-70222** **516-56-01**
Langley Research Center, Langley Station, Va.
**HYPERSONIC AIRCRAFT SYSTEMS TECHNOLOGY**
R. E. Bower 804-827-3285
(505-11-31; 505-04-31; 501-22-06)

The purpose of this work is to provide the technology required for flight demonstrations and tests of advanced propulsion structural systems associated with achieving efficient sustained hypersonic flight. In addition, this work is to support jointly with USAF the configuration development, thermal protection system verification and rocket engine selection for the test vehicle (X-24C) on which the experiments would be carried. A joint USAF-NASA an hoc committee has identified the need for the development and refinement of a research airplane concept capable of meeting the flight research requirements of both agencies. Detailed work on configuration development including integration of the major flight experiments such as a scramjet will be conducted. Further, the verification of the thermal protection system and studies leading to the final selection of the rocket primary propulsion system will be conducted. In addition, this program (in cooperation with the R&T disciplinary research programs) will develop the technology for advanced systems demonstrations for eventual flight test on the X-24C. Technology development leading to the fabrication and ground test of a flight-weight scramjet module designed to fully integrate with the vehicle as well as the development and test of liquid hydrogen fuselage tanks and advanced structural panels will be sponsored under this RTOP.

**W77-70223** **516-56-02**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**X-24C TECHNOLOGY SUPPORT**
Jack L. Kolf 805-258-3311
(516-56-01)

A joint USAF/NASA Ad Hoc committee has identified the need for the development and refinement of a research airplane concept capable of meeting the flight research requirements of both agencies. Detailed work on configuration development, including integration of the major flight experiments such as a SCRAMJET, will be conducted. Furthermore, the verification of the Thermal Protection System and studies leading to the selection of the Rocket Propulsion System, will be conducted.

**W77-70224** **517-51-01**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**TRANSONIC AIRCRAFT TECHNOLOGY (TACT)**
W. D. Painter 805-258-3311
(517-51-01)

The objective of this effort is research and development of a complete system for obtaining in-flight smooth contour changes to the wing aerodynamic shape. This system, referred to as a Mission Adaptive Wing, will employ a combination of aerodynamics, structures, and flight control technologies to achieve improved aerodynamic efficiency of the wing over a wide range of flight conditions. This joint NASA/USAF program will be conducted in accordance with a Memorandum of Understanding which is currently being reviewed. Preliminary Mission Adaptive Wing "configuration design and analysis" studies have been completed under AF contract NAS F-33615-75-C-3121 (General Dynamics Corp.) and F-33615-75-C-3122 (Boeing Aerospace Co.). New contracts have been awarded for Mission Adaptive Wing "Pre-design studies, AF contract N F-33615-75-C-3073 (Grumman Aerospace Corp.), AF F-3361576-C-3106 (General Dynamics) and F-33615-76-C-3107 (Boeing Company) which will be completed during the spring of 1976. The Langley Research Center will have the lead responsibility in the configuration development with ARC providing additional wind-tunnel test supports.

**W77-70225** **517-51-02**
Ames Research Center, Moffett Field, Calif.
**F-111 TACT RESEARCH AIRCRAFT**
R. H. Petersen 415-965-6463
(517-51-01; 517-51-03; 505-11-41)

The overall objective of the Transonic Aircraft Technology (TACT) program is to provide a 'proof-of-concept' research flight demonstration of recent advances in supercritical wing technology leading to the development of design criteria for future military and civil aircraft. Specifically, the effort at the Ames Research Center will be to provide thorough wind tunnel investigations as the basis for prediction of aerodynamic performance, stability, control, buffeting characteristics, static pressures, and structural loads of the TACT airplane. Correlation of the predicted characteristics based on the wind tunnel results with full-scale flight test data is a further major objective. Current projections are that all wind tunnel test data required for the correlation of wind tunnel and flight test will be obtained by end of FY-77.

**W77-70226** **517-51-03**
Langley Research Center, Langley Station, Va.
**TRANSONIC AIRCRAFT TECHNOLOGY (TACT)**
R. E. Bower 804-827-3285
(517-51-01; 517-51-02)

The overall objective of the Transonic Aircraft Technology (TACT) program is to provide proof-of-concept of supercritical

airfoil technology in the transonic and low supersonic flight regimes and to provide design criteria for the design of future military and civil aircraft. The effort at the Langley Research Center will be to analyze and document wind tunnel test results of the nozzle thrust-minus-drag and fuselage afterbody drag coefficients for use in correcting static aerodynamic data to full scale airplane values for various engine power settings. The Langley effort will also provide technical assistance for the correlation and analysis of the wind tunnel and flight aerodynamic data. A large portion of this technical effort in the immediate future will be the determination of the aeroelastic deformations of the TACT configuration to be used in the wind tunnel to flight data correlation. Additional technical effort will be directed toward analysis and correlation of the wing boundary layer characteristics including shock-boundary-layer interaction.

**W77-70227** **517-51-05**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**TRANSONIC AIRCRAFT TECHNOLOGY (TACT II)**
W. D. Painter 805-258-3311
(517-51-01)

The objective of this effort is for research and development of a complete system for obtaining in-flight smooth contour changes to the wing aerodynamic shape. The complete system referred to as a Mission Adaptive Wing, will employ a combination of aerodynamics, structures, and flight control technologies to achieve improved aerodynamic efficiency of the wing over a wide range of flight conditions. This joint NASA/USAF program will be conducted in accordance with a Memorandum of Understanding which is currently being reviewed. Preliminary Mission Adaptive Wing 'configuration design and analysis' studies have been completed under AF contract NAS F-33615-75-C-3121 (General Dynamics Corp.) and F-33615-75-C-3122 (Boeing Aerospace Co.). New contracts have been awarded for Mission Adaptive Wing 'Pre-desing' studies, AF contract No. F-33615-C-3073 (Grumman Aerospace Corp.). AF F-33615-76-C-3106 (General Dynamics) and F-33615-76-C-3107 (Boeing Company) which will be completed during the spring of 1976. The Langley Research Center will have the lead responsibility in the configuration development with ARC providing additional wind-tunnel test supports.

## Aeronautics Experimental Programs

**W77-70228** **723-01-01**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**HIGHLY MANEUVERABLE AIRCRAFT TECHNOLOGY (HIMAT) - FLIGHT RESEARCH PROGRAM**
G. P. Layton 805-258-3311
(505-06-44)

This RTOP covers the flight-test phase of a program to provide improved technology for the design of highly maneuverable aircraft. Present design restraints will be relaxed to permit complete freedom in the application of state-of-the-art system such as integrated, computerized controls, composite structures, propulsion augmentation of lift and control and the like in order to achieve maximum benefits from synergistic effects. The complex and innovative configurations such as the HiMAT designs can only be validated and the high risk technology matured for manned vehicle application through extensive testing of the complete configuration in the real and dynamic environment of flight. The high level of technical risk inherent in the HiMAT designs precludes their application to manned prototype vehicles because of pilot safety concerns and the enormous cost of these aircraft. This program will use large scale free-flying models controlled by remote piloting techniques to acquire actual flight-test data at a minimum cost. The facility for these tests exists at DFRC and is currently being extended to handle supersonic vehicles.

**W77-70229** **723-01-02**
Langley Research Center, Langley Station, Va.
**HIGHLY MANEUVERING AIRCRAFT TECHNOLOGY**
R. E. Bower 804-827-3285

The objective of this research is to support the HiMAT program through the investigation and development of the technology base required for the design of new highly maneuvering aircraft concepts, and through the actual evaluation of the Rockwell HiMAT configuration. The study of a highly integrated canard-wing concept will be pursued with the objectives of defining the stability, control and performance characteristics at high angles of attack. The development of computerized logic to control fighter aircraft in simulated, interactive air combat against human pilots will be continued, as will research in innovative guidance and display systems. Promising ideas for obtaining high aerodynamic performance for maneuvering fighter aircraft will be examined analytically and experimentally with primary emphasis on investigating their aerodynamic performance, propulsion, stability, and control characteristics. Representative promising concepts which may be incorporated into the basic canard-wing concept include a high aspect ratio, two-dimensional, vectoring nozzles; new and innovative wing designs including aeroelastic tailoring; and anti-spin devices. The experimental studies will be conducted primarily in the Langley 16-foot, full-scale, spin, 16-foot transonic dynamics tunnel, and simulator studies in the Differential Maneuvering Simulator (DMS).

**W77-70230** **734-01-0**
Langley Research Center, Langley Station, Va.
**COMPOSITE COMPONENTS (ACEE)**
H. T. Wright 804-827-3265
(734-02-01; 505-02-41)

The objective of the composite components program is to accelerate the introduction of composite structures in commercial transport aircraft. This will be accomplished through the progressive introduction of selected components in current aircraft production. Design technology for typical secondary structure components and medium sized primary structures will be developed. Manufacturing processes suitable for production will be developed and verified. Performance of composite structure in an operational environment will be verified through comprehensive ground testing followed by extensive flight service on commercial aircraft.

**W77-70231** **734-01-02**
Lewis Research Center, Cleveland, Ohio.
**COMPOSITES SYSTEMS TECHNOLOGY**
R. H. Johns 216-433-4000
(505-01-34; 505-02-43)

The general objective of this program is to provide supporting technology that will foster the timely introduction of composite materials as fan blades in advanced turbine engines. The initial work will consist of two major courses of action. In one activity, the superhybrid design concept will be extended to include superhybrid shells bonded to spars having integral root attachments as a means of achieving a fan blade with FOD resistance consistent with FAA requirements. In the other activity (closely related to the first), the effects of specific environmental factors (such as temperature, moisture, and aging) on foreign object damage (FOD) resistance will be studied. In addition, the effectiveness of various bonding materials, outer skin layers, and leading edge protection devices will be determined.

**W77-70232** **734-02-01**
Langley Research Center, Langley Station, Va.
**COMPOSITE WING**
H. T. Wright 804-827-3265
(734-01-01)

The composite wing is part of the ACEE composite structures program. The objective is to develop design and manufacturing technology to accelerate the introduction of composite structures in new and derivate commercial transport aircraft. Multiple contracts for conceptual design studies of composite wings for transport aircraft will be awarded. These contracts will lead directly to proposals for a wing development and flight service program, and a single contractor will be selected to continue the development effort. A full-scale wing will be built and certificated for commercial service. The wing will undergo flight testing followed by flight service in an airline operating environment. Flight service will continue for a minimum of five years.

**W77-70233** **738-01-01**
Lewis Research Center, Cleveland, Ohio.
**QUIET CLEAN SHORT-HAUL EXPERIMENTAL ENGINES (QCSEE)**
Carl C. Ciepluch 216-433-4000
(505-05-22)

The objective of this program is to design, build and test experimental engines to consolidate and demonstrate the technology needed for very quiet, clean and efficient propulsion systems for economically viable and environmentally acceptable powered lift short-haul aircraft. Two experimental propulsion systems, engines and nacelles, one for under-the-wing and one for over-the-wing installation, will be designed, built, tested and delivered to the Lewis Research Center. Acoustic and aerodynamic performance testing in wing/flap system installations will be conducted to verify system characteristics and achievement of program goals.

**W77-70234** **743-01-01**
Langley Research Center, Langley Station, Va.
**SCAR - STRUCTURAL CONCEPTS**
R. R. Heldenfels 804-827-2042
(743-01-11; 743-01-12; 743-01-22)

The objectives are to: (1) assess merits of structural arrangements, concepts, and materials for advanced supersonic aircraft and determine best approaches; (2) perform studies to develop baseline structure for arrow-wing aerodynamic configuration and guidelines for future research; (3) acquire analysis and design tools for future in-house studies of advanced configurations; (4) develop advanced composite panels for low-weight and high fracture resistance; (5) assess impact of application of composite structures in a continuation of Boeing structural concept study contract; (6) perform sensitivity studies in-house with Vought team to examine impact of structural modifications and composites on aeroelastic behavior; and (7) test advanced composite panels in-house to develop a fracture theory.

**W77-70235** **743-01-02**
Ames Research Center, Moffett Field, Calif.
**FUEL TANK SEALANTS**
D. R. Chapman 415-965-5065

The objective of this RTOP is to develop fuel tank sealants which offer long service life under conditions encountered in advanced supersonic aircraft. The specific objectives are to: synthesize, characterize and vulcanize sealant elastomers; study mechanism(s) by which they deteriorate on exposure to heat both in the presence and absence of fuels; select optimum sealant and determine its thermophysical and dynamic properties; and evaluate it by performing appropriate environment and flight testing. Novel elastomers will be synthesized as candidate fuel tank sealants designed to meet flight requirements of Mach 2.7-3.0 and higher. The mechanism and kinetics of thermal degradation of these sealants will be investigated. Gum sealants will be selected, compounded and tested under simulated fuel tank conditions to establish their long term service life. The optimum sealant will then be applied to a fuel tank in an advanced aircraft and flight-tested.

**W77-70236** **743-01-11**
Langley Research Center, Langley Station, Va.
**SCAR - COMPUTER-AIDED DESIGN**
R. R. Heldenfels 804-827-2042
(743-01-01; 743-01-12; 743-01-22)

The objectives are to: (1) develop computer-aided design methods for supersonic cruise vehicles with particular attention to aeroelastic, flutter, thermal stress, and fatigue and fracture considerations; (2) under grants and contracts, extend or improve computer codes for design-oriented aerodynamics, fatigue and fracture design, and flutter optimization; and (3) integrate a flutter optimization computer code with a large-scale structural analysis code to produce a flutter design module.

**W77-70237** **743-01-12**
Langley Research Center, Langley Station, Va.
**SCAR - LOADS AND AEROELASTICITY TECHNOLOGY**
R. R. Heldenfels 804-827-2042
(743-05-04; 743-05-31; 743-01-11)

Under the specific objective to establish an expanded supersonic structures and materials technology base in parallel with the expansion of other supersonic disciplinary technologies which will permit major reductions in structural weight by research on new materials with satisfactory fatigue, fracture, and lifetime characteristics under supersonic cruise conditions,' the objective of this plan is to develop, in-house and with contract support, technology in the area of loads and aeroelasticity to a sufficient state of readiness to provide an adequate base for confident initiation of development of advanced supersonic cruise aircraft. A multi-faceted approach will be used to meet this objective. The development of advanced flutter analysis theories and parametric wind tunnel flutter tests will provide improved inputs to the flutter design particularly in the transonic and low supersonic speed regimes. Loads analysis techniques to include aeroelastic and nonlinear transonic effects will be developed. Both existing and new wind tunnel experimental results will be used to verify and improve analysis techniques. Acoustic pressure inputs from the engine exhaust will be quantified and the response of various structures will be analyzed. A program to predict aircraft landing, taxi and takeoff motion will be formulated and the benefits of an active landing gear on the ride quality and loads will be determined.

**W77-70238** **743-01-13**
Langley Research Center, Langley Station, Va.
**SCAR - ATMOSPHERIC TURBULENCE**
R. R. Heldenfels 804-827-2042

The objective is to establish and expand supersonic structures and materials technology base which will permit reductions in structural weight for supersonic cruise conditions and to establish the aeroelastic behavior of highly flexible long and slender aircraft in the transonic and supersonic flight regime. Detailed definition of power spectra of turbulence and wave motion characteristics present in the atmosphere in various meteorological conditions will be obtained. Special emphasis will be placed on the determination of the spectral shape at wavelengths of 30,000 ft. or greater and altitudes of 30,000 to 65,000 ft. Meteorological conditions will include jet stream, mountain waves, and near thunderstorms as well as earth boundary turbulence measurements, the latter primarily for instrumentation verification. Consistency of spectra and directional characteristics of wave phenomena will be investigated. All measurements will be made utilizing the same instrumentation system and same data processing procedure. Instrumentation includes low inertial flow vanes, an inertial platform for measuring aircraft motion angles, platform-mounted accelerometers integrated for aircraft velocities, and rate gyros for angular rates. A total of 60-90 flights should yield sufficient data to accomplish the objectives.

**W77-70239** **743-01-22**
Langley Research Center, Langley Station, Va.
**SCAR - MATERIALS APPLICATION**
R. R. Heldenfels 804-827-2042
(505-01-34; 524-71-01)

The objective of this program is to advance composite and titanium materials and structural component technology to achieve longtime structural integrity and low weight in supersonic cruise aircraft structures. The technology development program will consist of development of advanced fabrication methods; performance of strength, fatigue, and fracture tests to establish structural integrity of materials and representative components; development of methods for acceleration of fatigue tests; performance of time-temperature-stress investigation to determine capabilities of advanced materials; development of new or improved resins, adhesives, and coatings; and fabrication, ground test, and installation of components on the YF-12 and Boeing 737 aircraft for flight service evaluation. It is anticipated that these programs will provide important advances in materials and structural component technology; help establish the future role of advanced composite materials; and indicate approaches for achieving lower structural weight, improved structural integrity, and lower fabrication costs for supersonic cruise aircraft.

**W77-70240** **743-01-23**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**SCAR STRUCTURES AND MATERIALS TECHNOLOGY**
Alan L. Carter 805-258-3311
(501-32-05; 501-32-06)

The objective is to determine the structural performance of candidate AST materials and fabrication techniques. A coordinated program of flight tests on the YF-12 airplane and supporting laboratory tests in the DFRC Heat Facility will evaluate such advanced concepts as corrugated and honeycomb sandwich, composites, skin-stringer concepts in a load and thermal environment.

**W77-70241** **743-02-22**
Ames Research Center, Moffett Field, Calif.
**SCAR - STRATOSPHERIC EMISSION IMPACT**
D. R. Chapman 415-965-5065
(989-15-20; 505-03-41; 176-10-11)

The basic objective is to develop an understanding of the interaction of supersonic jet exhausts with the upper atmosphere to provide data which can be used to assess wake impact on the natural atmospheric composition. Detailed objectives are to determine composition of the jet wake and the perturbations (chemical, fluid-dynamic) in the stratosphere caused by the passage of supersonic aircraft in a specified air corridor, and develop and apply advanced instrumentation to measure these trace constituents in the stratosphere. The Stratosphere Jet Wake Program will complete its studies with near-wake assessments concluding in mid-FY 77, and far-wake evaluations, if warranted, through FY 77. Integral with these activities is completion of an advanced instruments development program. The near-wake studies involve the use of newly available instruments on a U-2 aircraft flown into the visibly-marked wake of a supersonic aircraft in the stratosphere to measure exhaust gases. These data are being used to improve and verify mathematical models of engine exhaust wake chemistry. Fluid-dynamic models of the wake are being verified by photographic methods which provide wake dimensions with time.

**W77-70242** **743-03-11**
Lewis Research Center, Cleveland, Ohio.
**SCAR NOISE REDUCTION TECHNOLOGY**
U. H. von Glahn 216-433-4000

The objective is to develop the technology required to quiet both conventional and advanced supersonic transport engines to levels acceptable to the community. The area of particular concern is the noise suppression of high velocity jets. Wind tunnel tests will be conducted using scale-model nozzles developed for advanced duct-burning turbofan engines using coannular flow nozzles to determine airspeed effects on the jet acoustics of such nozzles.

**W77-70243** **743-03-21**
Lewis Research Center, Cleveland, Ohio.
**SCAR POLLUTION REDUCTION TECHNOLOGY**
R. A. Rudey 216-294-6160
(505-03-32; 505-04-31; 743-02-22)

The objective is to minimize the amounts of pollutants being discharged by aircraft engines into the upper atmosphere, by improving combustor and/or augmentor designs. Achieving low levels of exhaust emissions from high altitude aircraft by improving combustion design principles is needed in order to minimize any potential interaction of combustion products with the ambient atmosphere. Reductions in combustor exhaust emissions are being sought in two efforts. The first, which has been completed, was directed toward modification to combustor hardware developed in the clean combustor program with emphasis placed on reducing oxides of nitrogen (NOx) at supersonic cruise conditions. The second approach, which is currently underway, is to evaluate novel and unique techniques to minimize NOx to the lowest values possible in combustion systems eventually applicable to aircraft engines. The first effort if aimed at the near term emission reductions for current study type engines, whereas, the second effort is geared toward developing technology for future supersonic aircraft engines. The evaluation of potential augmentor emission reductions will be used to assess the impact that well designed augmentors would have on total engine emission levels. An augmentor (duct heater) concept evaluation program and an off design evalution of ultra-low cruise NOx emission (1 g NO2/KG fuel burned) combustor concepts has been initiated. Design and fabrication of a full annular version of the ultra-low NOx concepts is being planned.

**W77-70244** **743-03-31**
Lewis Research Center, Cleveland, Ohio.
**SCAR INLET STABILITY SYSTEM**
K. W. Hiller 216-433-4000

The objective is to demonstrate an improved inlet stability system for supersonic, mixed-compression inlets. The system would allow inlets to operate at a higer pressure recovery with fewer inlet unstarts than at present. Wind tunnel tests of a system using mechanical relief valves in a full-scale YF-12 inlet have been completed. The feasibility of flight testing the system on a YF-12 aircraft is being considered.

**W77-70245** **743-03-51**
Lewis Research Center, Cleveland, Ohio.
**SCAR - TECHNOLOGY-UNIQUE COMPONENTS**
R. A. Signorelli 216-433-4000

Advanced aircraft that must perform efficiently over a wide range of subsonic and supersonic flight speeds may employ variable bypass engine cycles which require a number of unique components. These components include a through-flow fan and sound suppression system which must provide a high level of performance over a wide range of flow conditions. The large complex sections must be fabricated with lightweight structural materials capable of operating at the high temperatures encountered at high flight speeds and in the hot section of the engine. Advanced composites provide the most promising materials for these structures. To provide the necessary high levels of performance and advanced materials for these unique components of variable bypass engines, the following major thrusts are included: (1) Advanced boron/aluminum composite materials for lightweight fan blades with improved impact resistance will be evaluated. (2) Structural and fabrication properties of an applicable high temperature composite material (silicon carbide in metal matrix) will be evaluated as fully as funding will permit for use in the hot sections of the engine. R and D funding is discontinued for FY 77 budget purposes. (3) Supersonic through-flow fan stages applicable to a supersonic cruise engine will be evaluated.

**W77-70246** **743-04-01**
Langley Research Center, Langley Station, Va.
**SCAR - AERODYNAMIC PERFORMANCE TECHNOLOGY (SYSTEMS INTEGRATION STUDIES)**
Robert E. Bower 804-827-3285

The objective of this program is to assess the impact of advanced technologies on the overall characteristics and mission capabilities of promising commercial and military supersonic cruise aircraft concepts. Integration studies will typically evaluate advances in aerodynamics/configurations, propulsion, structures, materials, and avionics. These studies will indicate favorable design trade-offs and point the directions for future productive research and technology activities. Throughout the studies, major consideration will be given to meeting noise and pollution constraints and to improving the energy utilization of supersonic cruise aircraft. The objectives of this program will be accomplished by an in-house team supported by nonpersonal services contract manpower and by several industry airframe teams who utilize the propulsion companies as subcontractors. The approach of these teams will be to assess the applicability and payoff of advanced technologies through detailed integration of these advanced technologies into a practical reference configuration of a supersonic cruise aircraft.

**W77-70247** **743-04-12**
Langley Research Center, Langley Station, Va.
**SCAR - AERODYNAMIC PERFORMANCE TECHNOLOGY (CONCEPTS)**
Robert E. Bower 804-827-3285

The objective of this program is to develop advanced

supersonic cruise vehicle concepts and to provide a source of experimental data which can be used in the optimization of these concepts. The goal is to provide fully integrated configurations which provide at least a 30 percent improvement in supersonic cruise efficiency while meeting the requirements of other disciplinary areas such as structures, propulsion, and flight controls. The research effort will be conducted in two ways. In one approach, in-house concepts will be analyzed and tested at subsonic, transonic, and supersonic speeds. Iterations will be made on the concepts, and wind tunnel models will be tested to establish trade information and to provide cause and effect relationships. In the other approach, cooperative NASA/Industry programs will be supported to develop data bases and trade information on promising airframe industry supersonic cruise vehicle concepts.

**W77-70248** **743-04-21**
Langley Research Center, Langley Station, Va.
**SCAR - AERODYNAMIC PERFORMANCE TECHNOLOGY (THEORY)**
R. E. Bower 804-827-3285
(501-06-01)

The objective of this program is to develop and validate methods for use in predicting overall aerodynamic characteristics and detailed load distributions of advanced supersonic aircraft configurations at both design and off-design conditions. Theoretical methods will be developed through contract and in-house studies and then evaluated with in-house tests of representative models of advanced supersonic aircraft. The studies will involve improvements to existing linearized-theory area-rule methods, and to the existing flow field methods. The off-design and critical design lead problems will be approached by including leading edge separation and reattachment in finite-element lifting surface theories.

**W77-70249** **743-04-31**
Langley Research Center, Langley Station, Va.
**SONIC BOOM**
R. E. Bower 804-827-3285

This RTOP is in support of the Supersonic Cruise A/C Research Program. The objectives are to provide an understanding of sonic boom generation and propagation, and to develop methods of estimation and minimization. In recognition of the substantial accomplishments already made for supersonic speeds approaching the hypersonic range, and in the absence of a national supersonic transport development program, the present research program is rather limited. Contract work has been terminated, and only a single university grant will be continued this year. An in-house program of analytic studies and wind-tunnel experimentation will be continued. The work will cover refinement of minimization techniques and their application in definition of configuration requirements for low levels of sonic boom.

**W77-70250** **743-05-04**
Langley Research Center, Langley Station, Va.
**SUPERSONIC CRUISE AIRCRAFT RESEARCH - ACTIVE CONTROL OF AEROELASTIC RESPONSE**
R. R. Heldenfels 804-827-2042
(512-53-01)

In order that dynamically scaled aeroelastic wind tunnel models may be used to study and validate active control applications for the minimization of aircraft aeroelastic response, the state-of-the-art of modeling technology, including model design and construction and testing techniques, will be advanced as required for active control applications. In addition to basic technique development, considerable emphasis will be placed on validating model procedures by correlating wind tunnel results with analytical and flight data. In order that future supersonic cruise aircraft can take full advantage of the potential benefits of active control for the minimization of aeroelastic response, research will be conducted to develop new active control concepts and approaches that are particularly applicable to SCAR class aircraft. These efforts are designed to help meet the general objective of establishing an expanded supersonic stability and controls technology base in parallel with the expansion of other supersonic disciplinary technologies which will provide major control system advances applicable to aircraft operating at supersonic cruise speeds.

**W77-70251** **743-05-22**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**SCAR - COOPERATIVE AUTOPILOT/SAS/PROPULSION CONTROL SYSTEM**
Berwin Kock 805-258-3311

Significant airplane flight path disturbances, attributable to the propulsion system, have been observed on the XB-70 and YF-12 airplanes at high speed. This RTOP is developing wind-tunnel and analytical techniques for predicting airframe/propulsion system interactions of advanced supersonic aircraft and determining the feasibility and benefits of a cooperative autopilot/SAS/propulsion control system. This goal is being pursued by conducting simulator and analytical studies to determine the possible benefits to be derived through the use of such an integrated control system on the YF-12. Contracts are being let for the design, construction, and installation of such a system on the YF-12. Flight tests are planned to verify the benefits that can be obtained by such a system in an operational environment.

**W77-70252** **743-05-31**
Langley Research Center, Langley Station, Va.
**ACTIVE FLUTTER SUPPRESSION OF SUPERSONIC CRUISE AIRCRAFT**
R. R. Heldenfels 804-327-2042
(743 05-04)

Active flutter suppression systems appear to be attractive for application to future flutter deficient aircraft designs from performance and costs points of view, since the potential exists for considerable weight savings as compared to traditional passive approaches of increasing structural stiffness and/or mass balancing. However, specific comparisons of active and passive solutions to increasing flutter speeds are needed so that the quantitative benefits of active systems can be determined. This is the objective of this RTOP. The objective will be reached by using contractor studies to compare active and passive flutter suppression applications to increasing the flutter speeds of particular structural configurations.

**W77-70253** **744-01-01**
Ames Research Center, Moffett Field, Calif.
**TILT ROTOR RESEARCH AIRCRAFT PROGRAM**
W. H. Deckert 415-965-5442

The objective is to design, develop, and conduct flight research in two Tilt Rotor Research Aircraft to prove the tilt rotor concept for potential military and civil missions. A program of direct supporting technology is also part of this RTOP. The Project Plan for Development of V/STOL Tilt Rotor Research Aircraft, Revision 3 dated January 1976 addresses the technical objectives, approach, justification, operating plan, environmental impact statement, milestone schedules, and the review and reporting for the subject project.

**W77-70254** **745-01-10**
Langley Research Center, Langley Station, Va.
**ROTOR SYSTEMS RESEARCH AIRCRAFT (RSRA)**
Howard T. Wright 804-827-3265
(505-10-24; 505-10-21; 505-10-23; 505-10-26; 514-53-01)

The Rotor Systems Research Aircraft (RSRA) objective is to develop and bring into operation two versatile flight research aircraft to provide economical rotorcraft research capability in the dynamic environment of flight. These research aircraft will provide research capabilities that cannot be duplicated in ground-base facilities. Rotorcraft research has previously been restricted because of the expense of developing specialized vehicles. The versatility of the Rotor Systems Research Aircraft will provide: (1) economical flight research of a wide variety of promising new rotor concepts, and (2) dynamic verification of rotorcraft supporting technology offering potential solutions to existing or anticipated problem areas. This is a joint project with the Army, in accordance with the Memorandum of Understanding between NASA and the Army dated November 1, 1974. The project will be managed through a joint Project Office

in accordance with the NASA/Army Rotor Systems Research Aircraft Project Plan which was jointly approved by NASA and the Army on February 23, 1973, and updated February 7, 1974.

**W77-70255** **769-01-01**
Ames Research Center, Moffett Field, Calif.
**AMST PROGRAM PARTICIPATION**
C. Thomas Snyder 415-965-5567
(769-01-02; 769-01-03; 769-01-04)

This RTOP provides for participation by NASA/Ames in the Air Force AMST Program and for the subsequent use by NASA of the AMST aircraft. The ARC role includes the planning, coordination and integration of NASA AMST flight experiments proposed by the four OAST research centers, in concert with the on-going Air Force flight test program and with the objectives of the NASA short-haul, R/STOL program. Further, ARC is responsible for contractual support of the NASA AMST flight experiments planning and implementation, including the complete experiments cycle from the design/feasibility hardware-integration phase through the data analyses and final report phase, with the participation of the individual NASA experimenters. Several broad ARC AMST flight experiment areas involve (a) studies of certification and airworthiness criteria for short-haul STOL transports, (b) studies of flight control systems, cockpit displays, and navigation system requirement for STOL terminal area flight operations and (c) correlation of methods for predicting vehicle characteristics with flight-measured characteristics. The first phase of the NASA AMST program participation is devoted to achieving the Air Force primary objectives and as much of NASA's technology-oriented research as can be accomplished concurrently without interference with the primary AF objectives. Subsequently, the aircraft would be turned over to NASA for tests more closely related to NASA's flight research objectives.

**W77-70256** **769-01-02**
Langley Research Center, Langley Station, Va.
**AMST EXPERIMENTS PROGRAM PARTICIPATION**
R. E. Bower 804-827-3285
(505-10-44)

The objective is to obtain, through participation in the U.S. Air Force advanced medium STOL transport (AMST) prototype aircraft program, upper-surface blowing and externally blown flap propulsive-lift flight research data. The Langley Research Center will participate in the AMST flight research program by supplying principal investigators to plan and help execute specific experiments in various discipline areas. A Langley representative will serve on the inter-Center Quiet Propulsive-Lift Technology (QPLT) Flight Experiments Working Group where the NASA experiments will be planned, evaluated, and integrated, into the joint flight test program with the Air Force-led flight tests and later NASA-led flight research utilizing both the Boeing YC-14 and Douglas YC-15 AMST aircraft.

**W77-70257** **769-01-03**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**AMST PROGRAM PARTICIPATION**
E. J. Montoya 805-258-3311
(769-01-01; 769-01-04; 769-01-02)

This RTOP covers DFRC activities pertaining to support of the joint Air Force/NASA AMST program and activities. Specific areas involved are: (1) participation on the AMST Joint Test Team; including flight test planning, developing NASA proposed flight experiments, developing research instrumentation and data acquisition requirements, in-house data reduction and analysis, and information dissemination; (2) proposing, reviewing, developing, initiating, and assisting other NASA Centers in implementing flight experiments derived from the OPLT Flight Experiments Working Group; (3) measuring the noise characteristics of the AMST aircraft; (4) investigating control system/stability and control requirements and operating environment for follow-on NASA Lead AMST flight experiments. All of the above listed activities were essentially new efforts in FY-74 covered under the R and T RTOP 769-89-01.

**W77-70258** **769-01-04**
Lewis Research Center, Cleveland, Ohio.
**AMST EXPERIMENTS PROGRAM PARTICIPATION**
M. F. Valerino 216-433-4000
(769-01-02)

This RTOP provides for Lewis Research Center participation in the joint Air Force/NASA AMST Program which includes definition of flight research experiments in the areas of propulsion system performance and noise to be conducted using the Boeing YC-14 and Douglas YC-15 prototype aircraft. LeRC will define, develop, and implement NASA propulsion-related flight experiments to be conducted during the Air Force led portion of the AMST flight test program, during joint NASA/airframe contractor flight tests involving only limited Air Force participation, and during the subsequent NASA-led flight research program.

**W77-70259** **769-02-01**
Lewis Research Center, Cleveland, Ohio.
**QSRA PROPULSION SUPPORT**
M. F. Valerino 216-433-4000

LeRC is supporting ARC relative to the propulsion systems of the OSRA aircraft. This support has included the study of engines potentially suitable for the research aircraft in achieving its powered lift, noise, and near terminal performance goals such that the most attractive concept can be selected. Based upon the results of these aircraft studies, the hybrid upper surface blowing system has been selected for incorporation into the Buffalo aircraft. These selections then resulted in the selection of the Lycoming YF 102 series turbofan engine as that most suited for the intended application. The engine support has included the determination of updating and refurbishment required to government-owned YF 102 engines to accommodate the needs of the research aircraft, the use of one YF 102 engine for supporting ground test studies by LeRC, and the provision of a non-operational mockup engine to the airframe contractor. The continuing engine support will include provision of the updated/refurbished/acceptance-tested engines for the flight aircraft and additional ground test studies as required. The effort also includes participating as required in all other propulsion aspects of the aircraft program.

**W77-70260** **769-02-02**
Ames Research Center, Moffett Field, Calif.
**QUIET SHORT-HAUL RESEARCH AIRCRAFT (QSRA) R/STOL**
W. H. Deckert 415-965-5662

This Project falls under the R/STOL Area Grouping. This RTOP covers the design, fabrication and ground and flight test of a propulsive-lift quiet short-haul research aircraft (QSRA). The QSRA research objectives are to obtain data for design and certification criteria for practical quiet propulsive-lift short-haul transport aircraft. Included will be determination of the effectiveness of an advanced propulsive-lift wing in providing good low-speed performance at low community noise levels for takeoff, approach and landing. Emphasis will be placed on obtaining flight data to determine the best mix of wing loading, propulsive-lift, direct flight path control, and gust and load alleviating active control. The project will include a low-cost modification of a NASA-owned C-8 Buffalo aircraft into an advanced hybrid/upper surface blowing propulsive-lift configuration using NASA-owned Lycoming YF-102 engines with A-9A gearboxes and accessories. Key design simplification guidelines are the use of a fixed landing gear, 160 knot maximum speed, +2g, -0.5g limit load, and design life of 500 flight hours. The flight research program covered under this RTOP consists of a brief contractor-conducted flight test program to assure airworthiness, and an initial NASA flight test program that includes definition of the research capability of the aircraft and interagency pilot evaluation. Not covered under this RTOP but briefly summarized herein for visibility is the NASA follow-on flight experiments program to obtain the data for establishing the design and certification criteria for quiet propulsive-lift aircraft.

# Space Research and Technology Base

**W77-70261** **506-15-22**
Langley Research Center, Langley Station, Va.
**ADVANCED ELECTRONIC AND MATERIALS SCIENCE**
P. F. Holloway 804-827-2893

Five related research efforts constitute this fundamental program. (1) Fundamental research on GaAs emphasizes device investigations and materials science to study the feasibility of high efficiency, high temperature, radiation-resistant epitaxial solar cells for space and terrestrial applications. Efficiency studies are focused on elimination of low response regions and improved cell structures, e.g., graded band gap cells. Radiation damage evaluation of cells and crystals provides material and device information for optimization of solar cells for long term exposure to ionizing radiation. (2) Powerful techniques of theoretical chemistry are used to investigate the molecular properties of matter, especially photo- and thermochemical reactions of short-lived intermediate gaseous species which are difficult to measure and are very important in atmospheric reactions. Sophisticated quantum calculations yield energies, structures, and reaction routes. (3) Floating gaussian orbital computations are maturing into a practical method for computing energy and structure to obtain general chemical trends and are used to predict chemical behavior of similar crystalline materials. (4) Studies of the chemiluminescence ozone detector focus on highly reproducible samples and on tests for interference by other gases. (5) A fundamental investigation of the effects of aerosol constituents on atmospheric chemistry and the use of atmospheric ozone to define aerosol composition is performed through heterogeneous chemistry and a study of surface phenomena.

**W77-70262** **506-15-25**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PROPERTIES OF MATERIALS FOR ELECTRONIC APPLICATIONS**
G. W. Lewicki 213-354-4530
(506-18-33)

This program pursues basic investigations into new technologies needed to meet NASA's requirements for electronics. Investigations are directed at thin metal-oxide-silicon (MOS) structures, Schottky-barrier solar cells, and superconducting quantum detectors. Thin MOS structures with oxide thicknesses of 100 A or less are being investigated in order to solve the basic instability problems in existing LSI (large-scale integration) technology. The critical region of field-effect devices is the oxide-silicon interface. Unique experimental probes recently developed at JPL, which include electron tunnel effects and X-ray photoelectron spectroscopy (ESCA, XPS), now permit direct study of the chemical and electrical characteristics of the interface. The thin MOS task uses these measurements of the chemical and electronic structure of the interface to establish the relationship between specific steps in LSI processing technology with the basic instability problems. This task also establishes the properties and limitations of thin MOS structures which are the precursers of ultra-high-density microelectronics. Another task is aimed at new methods of achieving low-cost, high-efficiency solar cells. Schottky-barrier solar-cell structures are being used to investigate the oxide-GaAs interface region electrically and chemically. Such interfaces can greatly modify the current transport through devices and has been shown to increase solar-cell efficiency by up to 60%. With the use of chemical-vapor-deposition technology, ultra-thin single crystals of GaAs can be developed for extremely light weight and lower cost, longer lifetime space solar cells, as well as advanced multilayer Schottky-barrier solar cells with potential efficiencies of 25%. Superconducting quantum detectors are being investigated for applications in the millimeter and far-infrared wavelengths. The approach includes the study and improvement of weak-link devices used directly as detectors, and as temperature-sensing elements of a composite bolometer. It also includes the study of such devices with an infrared-active overlay to improve sensitivity and selectivity. Studies are also being undertaken to increase operating temperatures in order to improve performance and reduce refrigerator requirements.

**W77-70263** **506-15-28**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**NON-METALLIC SUPERCONDUCTORS**
G. Lewicki 213-354-4530

The primary objective of this program is to determine the possibility of synthesizing a high temperature superconductor, e.g., T sub c approximately 100 K. It is now known that a high temperature superconducting state is theoretically possible in materials which have highly anisotropic crystal structures. The superconductivity results from either a dominant excitonic interaction or via an incommensurate charge density wave (Frohlich mode). These mechanisms are significant only in quasi-one dimensional materials in which the atoms or molecules form arrays of linear chains. The important structural and chemical features required to enable a quasi-one dimensional (1D) materials to superconduct at high temperatures are fairly well known. The basic problem is to incorporate these desirable features into a real anisotropic crystal structure. Organic charge transfer salts and organo-metallic compounds provide the most promising systems for investigation from structural, chemical and electronic standpoints. The attainment of a high temperature superconductor would make a profound impact on modern technology. Typical potential applications would be for spaceborne and airborne superconducting generators and motors and for magnetic field confinement of plasmas in fusion reactors. The approach involves a coordinated chemistry and physics effort directed towards the investigation of quasi-1D organic and organometallic compounds. The chemistry effort will emphasize synthesis of quasi-1D structures containing: (1) cation radicals and anion radicals with large heteroatoms and, (2) organometallic coordination compounds of rhodium and iridium. The physics effort will involve electrical, magnetic, optical and X-ray measurements of the synthesized compounds. Prof. A. Hermann of Tulane University, under a subcontract, will provide single crystal thermoelectric power measurements to assist the JPL physics effort. Prof. W. Little of Stanford University, also under a subcontract, will carry out normal reflectivity measurements and provide a theoretical investigation of the excitonic mechanism for high temperature superconductivity in the organic charge transfer salts.

**W77-70264** **506-16-11**
Ames Research Center, Moffett Field, Calif.
**SURFACE PHYSICS**
D. R. Chapman 415-965-5065

Studies are being conducted to expand the understanding of surface and interfacial properties and surface-environment interactions to determine their effects on material behavior. These studies range from describing the changes in surface properties that result when atomic and molecular beams interact with solid surfaces to the study of the growth characteristics of thin films and of the nature of composite interfaces. Other experimental studies will involve high resolution electron microscopy in ultrahigh vacuum to evaluate the feasibility of developing 'electron transparent model catalysts' for fundamental studies of the effect of metal particle size and structure on catalytic reactions. The surface mobility of catalytically active metal particles (10 to 100 A) and the resulting effect upon the aging properties of supported metal catalysts are also being investigated by in-situ TEM. LEED/Auger/work function/thermal desorption studies of the interaction of metal vapors and gaseous species with metal and graphite surfaces will continue and will be concentrated on determining the effect of thin intermediate oxide layers on the atomistic properties of metal/metal interfaces. The Auger-microprobe has been further developed and will be applied to specific test specimens.

**W77-70265** **506-16-12**
Lewis Research Center, Cleveland, Ohio.
**PHYSICS AND CHEMISTRY OF SOLIDS**
R. A. Lad 216-433-4000

The objectives are to increase the base of understanding of the relationships between the electronic, atomic, molecular and microscopic structures of solids and their useful mechanical structural and chemical properties: the focus is mainly on basic problems associated with metal matrix composites, the hot corrosion of superalloys and the functioning of the silver-zinc battery. The emphasis in composites is on phenomena which contribute to low impact strength, a wide spread in mechanical

properties and deterioration during thermal cycling. The emphasis in hot corrosion is on the study of the kinetics and mechanism of the reaction, the composition of the gas phase and solid phase chemical species involved, and the thermochemistry and thermodynamics of the reactions. The battery research is focussed on the chemical and electrochemical processes occurring during operation and charging.

**W77-70266** **506-16-12**
Ames Research Center, Moffett Field, Calif.
**PHYSICS AND CHEMISTRY OF SOLIDS**
D. R. Chapman 415-965-5065

The objective is to develop efficient computer programs to calculate reliable wave functions for ground and excited states of atoms, diatomic molecules, polyatomic molecules, and solid state matter. These wave functions will in turn be the basis for precision calculation of many basic properties of matter such as bond dissociation energies, radiation transition probabilities, dipole moments, Auger transitions, chemical rate coefficients, and solid state properties. Computer codes for calculating wave functions using the CDC 7600 and the parallel processing feature of the ILLIAC IV will be developed. These codes will be compared with the best available numerically computed wave functions to assure the coding is reliable; then, they will be used to calculate larger expansions of these wave functions, which will be more precise than heretofore, and also wave functions for species which have not yet been computed. Several low-lying states of each symmetry type will be computed and optical transition probabilities between these states will be evaluated. The work will emphasize chemisorption, corrosion, monolayer growth, catalysis and band structure calculations.

**W77-70267** **506-16-14**
Lewis Research Center, Cleveland, Ohio.
**INTERDISCIPLINARY LABORATORIES FOR MATERIALS RESEARCH**
R. A. Lad 216-433-4000
(506-16-12)

The objectives are: (1) to obtain new understanding of the relationships between electronic, atomic, molecular, and microscopic structures of solids and their useful mechanical, structural, electronic, and chemical properties; and (2) to employ the expertise existent in universities to obtain knowledge in those areas of direct interest to NASA long range programs. Interdisciplinary and multidisciplinary research involving several departments is conducted at Rice University in areas recommended by consultations with a committee composed of representatives from Headquarters, LeRC, LaRC, and ARC. Research areas under study are stress corrosion and hydrogen in metals, materials for optical and magnetic memories, polymer and high temperature materials.

**W77-70268** **506-16-17**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**VISCOELASTIC PROPERTIES OF POLYMERS**
R. R. McDonald 213-354-6186

This is a program of fundamental research on the mechanical behavior of polymers. It is intended to determine the molecular parameters which control rheological behavior. This has been successful in simple amorphous rubbery systems which are not chemically reacting. The goal now is to extend this work first to longer times, where degradation may set in, and then to shorter times, where the material is glass-hard. At the same time a modified theory must be developed to describe crystalline and polyphase systems. The general approach involves the syntheses of both new and modified polymeric and prototype chemical structures, the characterization of these materials and the determination of chemical structure, morphology and property relationships. Applications for the mechanical properties work might range from improved solid propellants, expulsion bladder and valve seat materials for liquid propulsion systems, sealants for high-speed aircraft, new types of reinforced plastics, and high reliability belts and tapes for spacecraft magnetic recorders.

**W77-70269** **506-16-21**
Lewis Research Center, Cleveland, Ohio.
**ADVANCED MATERIALS AND MANUFACTURING PROCESSES**
N. T. Saunders 216-433-4000
(506-16-16; 506-16-21)

The objectives of this program are to characterize the suitability of present materials and to generate concepts for improved materials and manufacturing processes for advanced space systems, such as power-generation, communications, and propulsion systems. This research program is being conducted as a combined in-house, contractual, and grant effort. The current projects include: (1) demonstration of the laboratory feasibility of new iron-base alloys with both high fracture toughness and high yield strength over a wide range of temperatures (-196 to 540 C); (2) improvement of the manufacturing process control of boron/aluminum composites to achieve more consistent properties and to reduce fabrication costs; (3) assessment of the potential of alumina/aluminum composites to achieve high stiffness/density ratios at lower cost than other aluminum-matrix composites; and (4) evaluation of advanced superalloys and related manufacturing processes to increase the capabilities of high temperature superalloy heat exchangers for future space power systems.

**W77-70270** **506-16-21**
Langley Research Center, Langley Station, Va.
**ADVANCED MATERIALS FOR SPACE**
R. R./Swann Heldenfels, R. T. 804-827-2042
(743-01-22; 524-71-01)

The objectives of this research are: (1) to identify mechanisms of mechanical property degradation in advanced materials such as metal matrix composites; (2) to expand capability to predict mechanical property degradation of these materials; (3) to define the operating conditions for which these materials are suitable, and (4) to modify the materials to improve properties and reduce degradation. Metal matrix composites such as Borsic/Ti, B/Al, and Borsic/Al, as well as other advanced structural materials, will be subjected to thermal, environmental and mechanical cycles. Residual mechanical properties will be evaluated, and degradation of these properties will be correlated with microstructural and physical changes. Analyses of diffusion, phase change, and chemical reactions will be developed, and these analyses will be applied to predict microstructural changes. Atomic models will be developed of point and extended defects and their interactions. These analyses will then be extended to predict residual mechanical properties directly in terms of thermal and loading histories. Finally, with this quantitative analysis, in terms of materials variables available, the materials will be modified to reduce degradation.

**W77-70271** **506-16-22**
Lewis Research Center, Cleveland, Ohio.
**MATERIALS FOR LUBRICATION AND WEAR IN MECHANICAL COMPONENTS**
W. J. Anderson 216-433-4000
(505-04-41; 511-54-01)

The objectives are to: (1) obtain greater understanding of the structure of materials to eliminate empirical approaches in the selection of materials for lubricants, seals, bearings and other mechanical components; (2) to extend the technology of application methods to improved materials and designs for optimized solid and fluid mechanics in mechanical components for present and anticipated extreme environments of aerospace devices; (3) the utilization of aerospace materials and tribological concepts for the general benefit of mankind; and (4) to pursue solutions to anticipated lubrication, hydraulics and mechanical components problems for aerospace vehicles such as the space shuttle engine and vehicle as well as for advanced aircraft.

**W77-70272** **506-16-31**
Lewis Research Center, Cleveland, Ohio.
**THERMAL CONTROL WITH HEAT PIPES**
James F. Morris 216-433-4000

The objective is to establish materials, designs, and processing for efficient, durable heat pipes for space applications in the cryogenic, ambient, superalloy, and refractory-metal temperature ranges. The approach is to screen compatibilities, evaluate performances, and determine lifetimes for selected heat-pipe-fluid,

wick, and envelope materials; designs; processing procedures; and operating conditions. These results will be used to propose and specify heat pipes for space applications in the various temperature ranges.

**W77-70273** **506-16-31**
Goddard Space Flight Center, Greenbelt, Md.
**SPACE VEHICLE THERMAL CONTROL, HEAT PIPES**
R. McIntosh 301-982-6071

The objective of this RTOP is to improve the quality and reliability of spacecraft, subsystem and sensor temperature control through the use of heat pipes. During FY 77 primary emphasis will be placed on design, fabrication, and testing of reliable low temperature heat pipes which can be used for cryogenic sensor temperature control and/or solid cryogen maintenance. As part of the testing program an experiment will be developed for flight aboard the TIROS-N spacecraft scheduled for launch in CY 78.

**W77-70274** **506-16-31**
Ames Research Center, Moffett Field, Calif.
**CONTROL OF ENVIRONMENTAL EFFECTS**
D. R. Chapman 415-965-5065

The objectives are: (1) to develop basic control mechanisms by which heat pipes may achieve variable conductance, feedback control, or thermal diode performance; (2) to improve liquid transport capacity and reliability; and (3) to participate in flight tests of advanced heat pipe technology to establish flight level confidence. Ames Research Center shall act as the lead OAST Center and provide guidance to OA, OSS, and OMSF in this capacity as a means of extending basic understanding into practical missions. Development of basic control techniques will be continued with sustained emphasis on cryogenic thermal diodes, cryogenic gas-controlled heat pipes, and gas absorption reservoir heat pipes. Liquid transport capacity and reliability will be increased through the continued development of non-arterial heat pipes, flexible arteries, the application of improved evaporative and arterial priming concepts, and continued research into electrically-driven pumping of fluids. The Ames Heat Pipe Experiment (AHPE) on OAO-3 and the Advanced Thermal Control Flight Experiment (ATFE) on ATS-6 will be supported. A high-performance cryogenic diode heat pipe for the upcoming TIROS-N Heat Pipe Experiment will be developed, tested, and delivered.

**W77-70275** **506-16-32**
Langley Research Center, Langley Station, Va.
**THERMAL CONTROL - SECOND-SURFACE MIRRORS**
E. E. Mathauser 804-827-2036

An experimental program is in progress to define, study, and solve the problems associated with utilization of second-surface mirror coatings for passive thermal control of spacecraft. The development of the technology necessary to economically utilize second-surface mirror coatings on large spacecraft surfaces will be emphasized. Experimental aromatic-heterocyclic polymers will be evaluated to provide improved radiation stability for the second-surface mirror coatings. The approach shall include: (1) understanding the principles of second-surface mirrors, determining the materials to be employed, and developing complete coating systems and procedures for their application to spacecraft; (2) the continued use of the Space Environmental Effects System facility to evaluate the radiation stability of thermal control coatings; and (3) the development of flight experiments to provide data necessary to utilize these coatings on spacecraft.

**W77-70276** **506-16-33**
Marshall Space Flight Center, Huntsville, Ala.
**THERMAL CONTROL COATINGS AND PHASE CHANGE MATERIALS**
D. W. Wilkes 205-872-2405
(506-16-35)

As a continuation of work in the thermal control field, efforts will be directed toward methods of improving NASA's capabilities of controlling spacecraft temperatures. The first task is to complete development of an improved white paint, Zn2TiO4 pigment, and to test this and other thermal control coatings for their environmental stability and contamination sensitivity. Task 2 is to further develop the Phase Change Materials technology. Lower temperature operation and higher cyclic heat loads require PCM technqiues and materials to be studied to provide operation at low temperatures (below -20 C) and at higher heat capacities. The third task is to prepare a revised edition of the 'Phase Change Materials Handbook.' The tasks covered by this RTOP have been defined to be 'essential' technology by the Space Transportation Systems Technology Thermal Control Working Group. They are Task 1: Thermal Control Coatings, Task 2: Phase Change Materials, and Task 3: Phase Change Materials Handbook.

**W77-70277** **506-16-36**
Langley Research Center, Langley Station, Va.
**SPACE DEBRIS STUDIES**
D. H. Humes 804-827-2977

The objective of this RTOP is to provide spacecraft designers with current knowledge of the meteoroid environment, manmade earth orbital debris, and the effects of these on space operations. Such knowledge is basic in insuring proper mission planning and implementation. A model of the meteoroid environment in the solar system is being generated. This model will account for the interplanetary meteoroid environment and the 'gravity well' effect of planets. All available data are being used in this effort. This is a long range effort ending in 1980. Laboratory experiments are part of this RTOP. The effects of meteoroid and manmade debris impacting on spacecraft and schemes to protect spacecraft against these hazards are being studied and evaluated empirically in the Langley Impact and Projectile Range. Meteor studies will be completed as part of this RTOP. Existing LaRC photographic data will be analyzed and reported for their relation to meteoroid properties of composition density, and structural strength.

**W77-70278** **506-16-41**
Ames Research Center, Moffett Field, Calif.
**PLANETARY ENTRY TECHNOLOGY**
D. R. Chapman 415-965-5065
(186-68-75)

The objective is to develop the aerothermodynamic and ablative heat protection technology required to design spacecraft for planetary entry, to evaluate heat shield design concepts for future space exploration vehicles capable of entering atmospheres at speeds to 50 km/sec, to obtain flight data on heat-shield performance, and to develop heat shields based on new concepts. The approach is to define the heating environments to be encountered; to minimize the heating rates and total heat loads by proper choice of trajectory, vehicle shape, and heat shield material; to evaluate available materials in simulated environments including a number of different atmospheric compositions and combined convective and radiative and convective heating loads; to develop new materials tailored to provide maximum heat protection in given environments. Heat shield materials capable of the severe entry conditions of the outer planets will be tested in arc jets and their performance evaluated. A comprehensive realistic description of the gas cap radiation environment coupled to the material responce for graphitic, silica and transpiration cooled heat shields will be performed by carrying out computations. The heat shield on the Pioneer-Venus Probe will be instrumented to obtain flight data. This data will be correlated with results from ground-based facilities and analytical techniques to further improve methods for predicting heat-shield performance.

**W77-70279** **506-16-42**
Ames Research Center, Moffett Field, Calif.
**THERMAL PROTECTION MATERIALS FOR SPACE TRANSPORTATION**
Dean R. Chapman 415-965-5065
(506-16-43)

The objective is to develop the thermal protection technology required for design of advanced space shuttle vehicles and earth-orbital spacecraft for the 1980's. This program will address (1) the improvement of current reusable surface insulation (RSI) materials and development of new reusable heat shield materials, and (2) the evaluation of advanced thermal protection concepts and materials that have promise for improved performance, weight and cost savings. The effects of cyclic arc plasma exposure on new TPS materials will be studied to determine changes in

crystallinity, morphology, chemical and physical properties that are related to TPS performance. The specific focus of the program shall be in two areas: (1) improvement of current reusable heat shield materials for advanced shuttle and other earth orbital vehicles, and (2) advanced TPS for future earth orbital vehicles for both NASA and DOD missions. Analytical and experimental studies will be conducted in-house on the specific areas of interest. A number of improvements for current silica RSI such as new coating system are under way. This research is expected to yield coatings stable to 2800 F. Among the systems to be evaluated in FY 77 are semi-rigidized alumina and mullite, composite silica/mullite composites and new coating systems that may be stable to over 3000 F. Low density PBI and silica cloth covered silica felts will be studied as candidates for thermal protection of advanced earth orbital vehicles.

**W77-70280** **506-16-42**
Langley Research Center, Langley Station, Va.
**THERMAL PROTECTION MATERIALS FOR SPACE TRANSPORTATION SYSTEMS**
R. R. Heldenfels 804-827-2042

The objectives of this RTOP are to provide heat shield testing to support the space shuttle program, and to develop improved thermal protection materials and systems for advanced vehicles such as a flyback booster. Available arc-tunnel and other facilities will be used as required to validate the space shuttle TPS. If problems are discovered in the course of this testing, in-house programs will be undertaken to find solutions. Environmental exposure testing of RSI will continue. Emittance measurements on shuttle TPS materials will continue. Technology studies of alternate shuttle TPS will be completed if facility time is available. For advanced vehicles, new materials and materials configurations will be developed with emphasis on metallic materials. High temperature creep will be studied; data will be generated on various alloys and a design methodology will be developed based on statistical analysis of the data. A model for cyclic creep will be developed. Thermomechanical processing techniques which improve creep resistance and other properties of materials will be evaluated.

**W77-70281** **506-17-11**
Langley Research Center, Langley Station, Va.
**LARGE ERECTABLE SPACE STRUCTURES**
R. R. Heldenfels 804-827-2042

The objective is to provide technology which will lower cost and improve the operational effectiveness of future space systems through the creation of new concepts for expandable structures needed for booms, antennas, platforms, solar arrays, and reflectors. The approach is to continue efforts to identify those NASA missions which require large space structures and define the critical structural requirements needed to accomplish these missions. Through combined inhouse and contractual studies candidate concepts will be developed and evaluated that will permit the erection in space of large structures with accurate geometrical shape. Four generic concepts will be investigated: deployable structures, erectable concepts for delivery by the present shuttle, structures that can be manufactured in space, and erectable structures with surface control. System studies will be performed to evaluate candidate concepts and to provide guidelines for the design of such structures. Efforts will be continued to define and develop a program plan for a FY 1978 new initiative for Large Space Structures Technology (LASS).

**W77-70282** **506-17-12**
Lewis Research Center, Cleveland, Ohio.
**COMPOSITE TANK TECHNOLOGY**
R. H. Johns 216-433-4000

The objective of this area of research is to develop high pressure, lightweight, filament-wound composite pressure vessel technology for containment of room temperature storables, gaseous pressurants, and cryogens for shuttle II and tug tankage applications. Due to the high structural efficiency of the constituent materials, a composite vessel is significantly lighter than an all-metal vessel. Calculations and subscale composite vessel test results indicate that weight savings of 20 to 30 percent can be achieved by using load bearing metal lined composite tanks instead of conventional all-metal designs. Our work with load-bearing lined composite tanks has been completed except for long term and cyclic loading tests and this type of composite vessel is currently being utilized for containment of gaseous pressurants on the shuttle. Composite tanks utilizing thin metal (nonload bearing) liners have a capability of providing even greater weight savings. Up to 40 percent weight reductions compared to current all-metal tanks are projected. The primary emphasis of our research now is to develop very lightweight composite tanks equipped with thin metal or polymer liners. The approach used for this work involves the design, fabrication, and testing of subscale (4, 8, and 15-inch diameter specimens) graphite fiber/epoxy and Kevlar 49/epoxy composite vessels equipped with thin titanium, aluminum, and Saran liners.

**W77-70283** **506-17-14**
Lewis Research Center, Cleveland, Ohio.
**COMPOSITE MATERIALS APPLICATION TO STRUCTURES**
R. H. Johns 216-433-4000

Composite materials offer a high potential for reducing the weight of many structural components. However, before full advantage can be taken of the unusual properties of composite materials in such applications, considerable design and material property information is needed. It is proposed that studies be continued that will develop analytical design techniques for: (1) predicting structural characteristics of given composite configurations and for optimizing composite structures for minimum weight, cost, and structural efficiency through finite element analyses such as NASTRAN. (2) Predicting high velocity impact characteristics. (3) Predicting defect growth and arrest under simulated service environments. It is also proposed that studies be continued that will experimentally determine the mechanical properties of appropriate composite systems under complex loadings and environments, i.e., multi-axial loading, cyclic loading, high velocity impact, and in the absence or presence of various representative defects. The results of this work will also serve to verify the analytical design techniques referred to above.

**W77-70284** **506-17-21**
Langley Research Center, Langley Station, Va.
**NASTRAN MAINTENANCE**
R. R. Heldenfels 804-827-2042
(141-93-11)

The objective is to maintain and improve NASTRAN as a NASA standard structural analysis tool. Planned improvements are selected from those most needed by space shuttle contractors, NASA Centers, and aerospace industry users. Capabilities final level of NASTRAN will be defined by FY-77. Plans will be established to transfer maintenance activities to a user supported mechanism by FY-78, and the NASTRAN maintenance activity in the Structures and Dynamics Division will be phased out by FY-79.

**W77-70285** **506-17-22**
Langley Research Center, Langley Station, Va.
**THERMAL/STRUCTURAL CONCEPTS FOR SPACE TRANSPORTATION SYSTEMS**
R. R. Heldenfels 804-827-2042
(524-71-01; 506-16-43; 506-16-21; 505-02-12)

The objectives are to: (1) develop and evaluate thermal/structural concepts needed for efficient, reliable and cost-effective space transportation systems; (2) evaluate the integrity and aerothermal performance of surface TPS and control surface dynamic seal concepts by tests in the 8-foot High Temperature Structures Tunnel (8' HTST) and the Thermal Protection System Test Facility (TPSTF); (3) maintain, operate, and improve these facilities; (4) conduct analytical and experimental studies required to establish design technology for hot structures concepts for future space transportation systems such as heavy lift launch and SSTO vehicles.

**W77-70286** **506-17-23**
Lewis Research Center, Cleveland, Ohio.
**FRACTURE CONTROL TECHNOLOGY OF METALLIC STRUCTURES**

R. H. Johns 216-433-4000

The major objective of this work is to provide the technology necessary for effective design, evaluation, and maintenance of structurally efficient and damage tolerant aerospace components. Fracture control developments oriented by the requirements of advanced space transportation propulsion systems will be emphasized. To achieve this objective, programs structured to provide fracture control methodology, supporting test data, and definition of the NDE capability necessary to assure reliable, long life, and lightweight structures for reusable weight-critical propulsion components will be conducted. Specific tasks will provide crack propagation data under service type loading conditions for materials of engineering importance to spacecraft propulsion system components. Included are materials such as 2219T-87 aluminum and 5A1-2.5Sn titanium. Inspection and proof test requirements and capabilities will be defined in terms of operational environment, operating stress levels and significant material characteristics.

**W77-70287** **506-17-25**
Langley Research Center, Langley Station, Va.
**ADVANCED METHODS FOR STRUCTURAL ANALYSIS**
M. F. Card 804-827-2551

The objective is to provide advanced design techniques including analysis and design methods needed for efficient, reliable, and cost-effective space vehicles. The approach is to: continue support of development of advanced computerized analysis of composite shells-of-revolution and panels using methods which are foolproof in requirements for users' skills because of the use of integration (the 'field' method) for solutions rather than more numerically uncontrolled algebraic solutions; continue support and improvement of analysis tools which determine linear/nonlinear stress behavior, buckling and vibration characteristics of two-dimensional shell structures; apply analysis to critical agency problems as required; and study effects of imperfections and damage in shell structures and panels to generate more rational design procedures. In-house efforts will be focused on studying new solution techniques which will permit in-depth, practical modeling of critical areas of structure. Methods to account for fluid interaction in numerical analysis for vibration of shells of revolution will also be pursued in-house.

**W77-70288** **506-17-26**
Langley Research Center, Langley Station, Va.
**COMPOSITE SPACE STRUCTURES**
M. F. Card 804-827-2551
(505-02-42)

The objective is to provide, through advances in the state of the art, efficient, cost effective structural concepts for future earth orbiting, planetary and deep space spacecraft and launch vehicles. Design concepts for ultra lightweight space structures will be investigated. Structural integrity of structures with surface densities of about one tenth of a pound per square foot will be studied in laboratory tests. Methods of design for composite shell structures will be developed. Advanced concepts for cylindrical shells will be investigated. To save costs, the feasibility of conducting curved panel tests in lieu of full-scale shell structures will be investigated. Buckling tests on a series of curved panels and a limited number of large shell structures will be conducted. Design concepts for very large space structural networks will be investigated both analytically and experimentally. The strength, stiffness, and thermal behavior of several structural elements will be investigated experimentally and the merits of various concepts will be determined.

**W77-70289** **506-17-27**
Langley Research Center, Langley Station, Va.
**FATIGUE AND FRACTURE OF COMPOSITE MATERIALS**
J. R. Davidson 804-827-3012
(505-02-31; 743-01-01)

In-house and contractual research will concentrate on developing engineering analyses which predict the fatigue lives and fracture strength of composite materials. Failure modes will be studied, and the relevant parameters which control failure modes identified. Specific studies include the analysis of stringer stiffened orthotropic sheets, tests of thermally cycled composite materials, and tests of bonded and mechanically fastened joints. Specific goals are to: (1) develop methods to predict the mode of failure and the useful safe life of composite materials proposed for use in composite structures, (2) refine a fatigue-life prediction model to include more modes of damage, and (3) refine a fatigue-life prediction method for notched composites to include a delamination mode.

**W77-70290** **506-17-31**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SPACE VEHICLE DYNAMICS**
R. R. McDonald 213-354-6186

The principal objective of this five-year effort is to perform research and advanced development in dynamics design, analysis, and testing in order to reduce the cost of future spacecraft and shuttle payloads. Shuttle payload related activities are to be coordinated with OSF. The research and advanced development plan coordinated with NASA Headquarters and other NASA centers will be pursued. Support will be provided to help coordinate the activities under this program. Wherever feasible, the tasks will use Viking Orbiter's and Mariner Jupiter Saturn's existing load analysis, test data, flight data and schedule data.

**W77-70291** **506-17-31**
Goddard Space Flight Center, Greenbelt, Md.
**PAYLOAD DYNAMICS**
J. P. Young 301-982-4964

The overall objective is to reduce the cost and increase the effectiveness of structural related flight assurance services for space flight hardware. This objective will be approached through a series of related tasks aimed at optimizing the cost of structural test and analysis services. The above objective will be met during FY 77 by performing the following tasks: (1) continued development of cost effective alternate approaches to creating shuttle payload environmental test requirements, (2) study of more cost effective use of highly skilled personnel in performing NASTRAN analysis through use of minicomputer, and (3) continued development of spacecraft past performance data from which cost versus risk tradeoffs can be made on future pre-shuttle and shuttle era programs.

**W77-70292** **506-17-31**
Langley Research Center, Langley Station, Va.
**SPACE VEHICLE DYNAMICS**
M. F. Card 804-827-2551
(506-17-32)

The objective is to provide dynamics technology to assist in launch vehicle design, to reduce cost of future space payload systems through the improvement of payload vibration analysis and test techniques, and to develop the technical understanding of the dynamics and control problems in very flexible space structures. The approach is to continue development of technology to properly define the dynamic environment experienced by a payload during shuttle launch. Efforts to understand how to analytically predict coupling of vibration behavior of individual components will continue. Major experimental efforts will be focused on studies of a model payload and carrier structure. Feasibility of mini-computer-controlled data acquisition and shaker control systems for dynamic simulations will be investigated. Model tests of a coupled shuttle system will be completed and analyzed. Correlation of data obtained on 1/8-scale models of the shuttle external tank, solid rocket booster, and mated configurations will be investigated. Flexible models will be built and tested with a view to understanding the dynamics and controlling the motion of large flexible structures.

**W77-70293** **506-17-31**
Ames Research Center, Moffett Field, Calif.
**SPACE VEHICLE DYNAMICS**
R. H. Petersen 415-965-5880
(505-02-21)

The objective of this research was to provide improved prediction methods and data on the dynamic loads resulting from aerodynamic noise. The research included basic experimental studies of surface pressure fluctuations due to attached and

separated boundary layers and shock waves at transonic, supersonic, and hypersonic speeds. Empirical formulae that predict the temporal and spatial characteristics of the nonsteady loads were being derived from these data. Wind tunnel test support and analysis was also being provided for the space shuttle development program to investigate aerodynamic noise inputs and response, and panel flutter. Aeroelastic effects on the stability and control of the space shuttle were also being determined using the FLEXSTAB computing program. Due to reductions in staffing, this RTOP will be terminated by October 1, 1976. Wind tunnel test support of the space shuttle will continue as necessary under RTOP 506-26-31.

**W77-70294** **506-17-31**
Marshall Space Flight Center, Huntsville, Ala.
**SPACE VEHICLE DYNAMICS**
R. S. Ryan 205-872-2481
(506-17-31)

The objective is to derive and develop space vehicle structural dynamic technology that will establish techniques and methods to produce more efficient designs with a lower cost. More accurate methods of predicting dynamic loads and the response of the structural system based upon tests of previous spacecraft structures will be developed. Also, improved methods for analytically calculating high-fidelity mathematical models of spacecraft and payloads and for redesigning to minimize selected responses will be devised. The following tasks will be undertaken to accomplish the objective: Task 62: Spacecraft Structural Reponse Prediction and Minimization, Task T1: Statistical Energy Analysis, and Task 71: Advanced Structural Element Implementation

**W77-70295** **506-17-32**
Langley Research Center, Langley Station, Va.
**DYNAMICS AND AEROELASTICITY OF SPACE TRANSPORTATION SYSTEMS**
R. R. Heldenfels 804-827-2024
(506-17-31)

The objective is to provide dynamic and aeroelastic technology for the shuttle development team to assist them in design of the vehicle, and to reduce the cost of future space systems through improvement of spacecraft acoustic and vibration analysis and test programs. Many of the previous studies in this area were oriented toward identifying potential problem areas requiring further research. Much of the current program is directed toward evaluation of identified potential problems areas, defining methods of alleviation, and validation of final design concepts with regard to dynamic loads and aeroelastic stability. The investigations will be primarily in-house with some contract support, and will make use of both analytical and experimental methods.

**W77-70296** **506-18-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ADVANCED IMAGING SYSTEMS TECHNOLOGY**
R. V. Powell 213-354-6585
(186-68-52)

The long-term objective of this RTOP is the development of imaging systems enabling technology to meet the anticipated widely varying requirements of future planetary and near earth imaging missions. The current objective is the development of solid state imaging sensor technology for Mariner and Pioneer class spacecraft, as well as earth-related imaging instruments, based upon charge-coupled device (CCD) technology. These devices have the potential advantages of small size, reliability, scan versatility, geometric fidelity, magnetic cleanliness, and very high sensitivity. Furthermore, they are expected to lead to an integral general purpose solid-state camera (excluding optics) with major cost savings to future missions. The first major goal, providing a 400x400 CCD array in a flight-worthy package, will be fulfilled by FY-77. The next vital step of providing the technology for a large, monolithic 800x800 array will also be completed by the beginning of FY-77. This will allow realization of the major program goal, a large, flight-worthy monolithic CCD area array sensor, by the end of FY-78. The technology advances resulting from this RTOP are being applied to specific OSS camera development programs for Jupiter Orbiter, and are providing the base technology for earth and planet related camera systems analyses for the Shuttle generation of missions. In addition, this program has already enabled production of one, and proposal of more, low-cost CCD cameras for earth-based astronomical purposes.

**W77-70297** **506-18-12**
Langley Research Center, Langley Station, Va.
**HIGH RESOLUTION SENSORS**
S. L. Ocheltree 804-827-2791

The broad objective of this research is to investigate advanced sensor concepts and develop sensor systems technology for remote and in situ sensing of the earth, aircraft, and spacecraft environments. Sensor concepts to be investigated are laser backscatter and fluorescence techniques for the measurement of water quality, salinity, and turbidity of bodies of water; and continuously tunable infrared laser techniques for high resolution absorption and emission spectroscopy of low concentration atmospheric constituents.

**W77-70298** **506-18-13**
Goddard Space Flight Center, Greenbelt, Md.
**ASTRONOMICAL HIGH RESOLUTION SENSORS**
J. T. Williams 301-982-5095
(502-23-54)

The objective of this RTOP is the development of high performance astronomical sensors which will complement the telescopes and optical instruments now being developed for use on shuttle astronomy flights and advanced NASA space astronomy missions. In particular, we will investigate: a photon counting TV using Intensified Charge Coupled Device (ICCD) arrays; development of larger area CCD arrays for photon counting applications; and development of a windowless Intensified Charge Coupled Device for far UV applications.

**W77-70299** **506-18-15**
Wallops Station, Wallops Island, Va.
**HIGH RESOLUTION SENSOR DEVELOPMENT**
H. H. Kim 804-824-3411

The objective of this study is to develop new electro-optical sensors which can be applied to the studies of earth environment or planetary exploration. Currently the use of lasers for various hydrospheric measurements is investigated in this program. The feasibility of applying laser induced phonon scattering phenomena (Brillouin) for underwater temperature measurement is being studied in the laboratory. At the same time, a laser sea-wave profilometer with proved range and resolution is undergoing a series of flight tests.

**W77-70300** **506-18-16**
Marshall Space Flight Center, Huntsville, Ala.
**MICROCHANNEL PLATE PHOTON COUNTING DETECTOR SYSTEM**
C. S. Bordelon 205-872-1575

Several future orbiting scientific payloads will require photon counting detector arrays. Development of these arrays will permit new scientific data to be obtained with ground-based telescopes and facilitate experiments with laboratory plasmas by replacing photographic film. Technical application of the devices include low light level imaging and control systems such as star-tracker sensors. Currently available devices have limitations in terms of photometric sensitivity and stability, spectral range, dynamic range, uniformity of response and time resolution. The objective of this affort will be to continue the development of the 2 X 1,024 array and proceed with testing of this unit in the laboratory and under actual field use, and to proceed with the development of an area array of at least 80 X 80 pixels. The approach is to design, produce and test MCP arrays with the total number of picture elements in excess of 1,000 and operating in the wavelength region of 3,000 to 8,000 A.

**W77-70301** **506-18-19**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**DEVELOPMENT OF SUBMILLIMETER WAVELENGTH RECEIVERS**
R. V. Powell 213-354-6586
(188-78-56)

This RTOP is for a four year program to develop low-noise, coherent, submillimeter-wavelength receivers. The goal of the program is to provide the technological developments necessary for constructing receivers operating up to 1,000 GHz frequency (0.3 mm wavelength) with noise temperatures less than 1,000 K. These receivers will be of importance to the following areas of the space program in the time period beyond 1980: (1) terrestrial atmospheric observations from aircraft and from Earth orbit, (2) astronomical observations from aircraft and from Earth orbit, (3) missions to planets and comets, and (4) supporting laboratory spectroscopy. A logical four year program will be followed to develop low-noise receivers operating at frequencies up to 1,000 GHz. Four major technical areas must be addressed: (1) development of efficient quasi-optical techniques for submillimeter receiver front ends, (2) development of techniques for efficient coupling of submillimeter radiation to nonlinear devices, (3) development of appropriate nonlinear devices capable of efficient operation at submillimeter wavelengths, and (4) development of local oscillator sources. Some of the new techniques to be developed here will initially be tested at frequencies in the 100-200 GHz frequency range, and will be applied to higher frequencies in steps where each step is an approximate doubling of the previous operating frequency. At each step a prototype receiver will be constructed and its performance evaluated.

**W77-70302** **506-18-21**
Langley Research Center, Langley Station, Va.
**ELECTRONIC DEVICES AND COMPONENTS**
J. E. Stitt 804-827-3745
(520-71-01; 506-15-27)

The objective is to develop advanced electronic devices and components required for application in future aerospace missions. Theoretical studies and laboratory investigations in selected areas of electronic materials, device concepts, and processes will be conducted in-house; and research contracts will be used to develop new and improved electronic devices and components. Those material and process technologies, which have the potential for providing improved and reliable electronic performance in cost effective devices and components, will be emphasized. Current efforts include the investigation of new and improved materials and processes for the development of sensing and data acquisition devices, data transfer devices, data processing devices, and data storage devices.

**W77-70303** **506-18-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**FIBER OPTICS FOR DATA TRANSMISSION AND PROCESSING**
R. V. Powell 213-354-6586
(506-18-21; 180-24-51)

The goal of the proposed effort is to apply the emerging technology of fiber optic data links to NASA needs, and to contribute to the advancement of the technology in selected areas. Development of fiber optic data transmission will support OAST goals both in terms of a great increase in mission capability and a decrease in mission costs. The initial effort has been strongly applications oriented, and has focussed on an on-site CCTV link application and shuttle CCTV application. Other applications will be considered as the work progresses, with particular attention given to identifying a digital link for future demonstration. The applications will set the requirements for our experimental work, and they will help to identify limiting technology. The long term objective is to provide technology for the application of fiber optics and integrated optics in a variety of space flight and ground applications in order to obtain benefits of lower costs, reduced weight, and improved immunity to noise pickup, electromagnetic interference and ground loops. During FY-77 the important elements of the shuttle CCTV system will be breadboarded, and environmental requirements of the space application will be investigated. In addition, an on-site CCTV link will be demonstrated, and a 1Km 50 Mb digital link breadboard will be tested.

**W77-70304** **506-18-31**
Marshall Space Flight Center, Huntsville, Ala.
**DESIGN, PROCESSING AND TESTING OF LSI ARRAYS**
J. M. Gould 205-872-3772
(506-18-33; 180-17-55; 506-18-33; 506-18-32)

The objective is to improve product uniformity and performance, and reduce the cost, size and power requirements of LSI circuits and hybrid devices for all NASA applications. Past results include: shorter design cycle 6 mo./6 wk.; cheaper product development $60K/20K; 10/1 lower power per gate; and 1,000/1 lower power memory bit. Future expectations are: 3/1 speed improvement with same low power; 10/1 cheaper electronic subsystems through automated techniques, and higher yield, higher degree of integration and advanced hybrid packaging. The approach is to provide the technology, techniques, equipments, and sources to insure that long-life LSI arrays can be produced economically and consistently by: (1) providing device sources and design and test software and procedures; (2) proving process feasibility and demonstrating software and equipment; (3) correlating yield, performance and process parameters; (4) creating controlled processing equipment sources; (5) implementing a controlled, processing facility and demonstrating techniques; (6) conducting feasibility studies and engineering evaluations of hybrid techniques; and (7) publishing guidelines, specifications and manuals.

**W77-70305** **506-18-32**
Marshall Space Flight Center, Huntsville, Ala.
**SCREENING AND RELIABILITY TESTING OF MICROCIRCUITS AND ELECTRONIC DEVICES**
L. C. Hamiter 205-872-4562
(506-18-31; 506-18-33)

The objective is to develop approaches for assessing and assuring predictable long-operating life of microcircuits and other electronic devices used in aerospace applications. A study will be initiated to identify problems associated with presently available hermetic microcircuit packages. This study will propose solutions to these problems. A comprehensive evaluation program will then be performed on packages designed to eliminate the failure mechanisms identified in the study. A program will be implemented to develop a system and refine the method for inspecting LSI microcircuits using the pulsed super-position optical scanning technique. The plastic encapsulated microcircuit test program will be completed. The results will be used to identify materials, processes, and test controls necessary for reliable plastic packages. The results will also be used to define system level test programs that can demonstrate the capability of plastic microcircuits in space applications. A test program to assess the reliability and identify the failure mechanisms of Integrated Injection Logic will be started.

**W77-70306** **506-18-33**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PREDICTABLE LONG LIFE COMPONENT TECHNOLOGY**
R. V. Powell 213-354-6586

The goal of this effort is to develop and establish methods for predicting the reliability of microelectronic circuits in the NASA unique environments which include long lifetimes, long exposure to radiation, and unattended operation. The NASA goals for increasing information return by 1,000X and reducing costs by 10X are not achievable without a major commitment to new LSI technology throughout the entire spacecraft design. This RTOP supports those NASA goals by providing the reliability base which will permit the application of LSI technology with the confidence necessary to achieve a wide variety of mission goals. Problems in basic device reliability and radiation tolerance that have been encountered during flight projects have cost NASA millions of dollars. The technology proposed herein is designed to circumvent many of those problems and thereby achieve a workable method that will reduce significantly the overall parts acquisition cost. In addition, an obvious cost reduction occurs simply because more functions per chip are possible. The approach is to understand and model the failure mechanism associated with the basic processes which characterize LSI technology. With this fundamental understanding, methods are devised which will enable a reliability assessment of a given process, and, in many cases,

provide the necessary information for modifying a process which could potentially lead to failure or undesirable degradation. The current emphasis is on MOS technology. It is felt that MOS will be the basic process for LSI applications for many years to come. Specifically, the current investigations include: oxide and metal instabilities, electrical and chemical diagnostics, hybrid packaging, and development of test structures. Specific RTOP target objectives are to: (1) establish basic CMOS life predictions techniques which include the known dominant failure mechanism, and (2) establish process controls for CMOS by late FY-77, and develop and verify CMOS test chips by late FY-78.

**W77-70307** **506-18-34**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**RADIATION HARDENED ELECTRONICS**
R. V. Powell 213-354-6586
(186-68-83)

Many types of MOS and linear bipolar IC's are susceptible to degradation and failure when subjected to moderate doses of ionizing radiation. There are desirable missions such as a Jupiter Orbiter wherein the spacecraft would have to function through a total dose of as much as 10 to the 6th power rads from the Jovian belts. For survival through such an environment with presently available devices, extensive shielding and sacrifice in spacecraft capability would be required. The overall objective of this RTOP in combination with RTOP 186-68-83 is to develop devices with improved radiation hardness and thereby enable greater returns from future Jupiter missions. The specific objectives of the task are: (1) to perform detailed radiation failure analysis on limited IC types; (2) to relate the failure cause to specific deficiencies in the device design, process practices and process control; and (3) to formulate guidelines of general applicability for radiation hardening of devices. The effort will be initiated in FY-77 and concluded in FY-78.

**W77-70308** **506-19-11**
Marshall Space Flight Center, Huntsville, Ala.
**INERTIAL COMPONENTS**
B. F. Walls 205-872-5910
(909-55-10)

The objectives are: (1) the development of a group of inertial sensors for precise rate and attitude sensing that can be used in a wide variety of future NASA applications -- these sensors will make use of the laser gyro inherent advantages of performance, reliability, cost, weight and power; and (2) the development of a redundant strapdown laser gyro inertial measurement unit using six laser gyros and six accelerometers for a highly reliable, low cost navigation system for future NASA missions. The approach is to: (1) investigate the fabrication techniques and environmental parameter effects on the ultimate performance and stability of the laser gyro components; (2) develop, test and evaluate laser gyro sensors for special applications of guidance, control and navigation; and (3) develop, test and evaluate a redundant strapdown laser gyro navigation system.

**W77-70309** **506-19-12**
Goddard Space Flight Center, Greenbelt, Md.
**ADVANCED COMPONENTS FOR PRECISION CONTROL SYSTEMS**
H. E. Evans 301-982-5194
(506-19-13; 506-19-14)

This task covers research, design, and evaluation of cost effective advanced components and control electronics for precision pointing applications and long duration missions. Components and control systems for both free flying spacecraft and shuttle based instruments are included. Precise pointing systems, prototype components and systems will be developed with: (1) broader dynamic range control capability, (2) greater power efficiency and linearity, and (3) increased reliability by elimination of life limiting elements. Components technology advancements are utilized which include technical innovations in the areas of electronic commutation, magnetic suspension and microprocessors. These concepts are utilized in cost effective precision control systems such as long, life efficient rotating systems, non-contacting vibration isolators, and controlled multi-axis scanning systems. New concepts in actuators, sensors, and non-contacting power and signal transfer are incorporated. Phase-lock velocity and position control systems utilizing these components form part of this task.

**W77-70310** **506-19-13**
Langley Research Center, Langley Station, Va.
**ADVANCED SPACECRAFT AND EXPERIMENT CONTROL SYSTEMS**
J. E. Stitt 804-827-3745
(910-35-02)

Technology will be developed to permit the design of cost-effective spacecraft and experiment control systems for earth orbital missions. Simulations will be made of new and existing control concepts for earth orbital vehicle/missions in order to determine required system and component performance. Effective system configurations, low-cost system integration, multipurpose operation, and component standardization will be used to reduce system and component costs while achieving required performance. Control software and hardware needs will be defined and development efforts undertaken. Critical hardware elements will be carried through laboratory developments to establish feasibility. This effort is directly coordinated with GSFC, JSC, MSFC, and JPL. GSFC developed components will be integrated into Langley control actuator hardware.

**W77-70311** **506-19-14**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**EXTENDED LIFE ATTITUDE CONTROL SYSTEMS (ELACS) FOR UNMANNED PLANETARY VEHICLES**
Robert V. Powell 213-354-6586
(186-68-54)

The long range objective of 'Extended Life Attitude Control System' (ELACS) is to develop and demonstrate a spacecraft control concept that is applicable to a wide range of unmanned, earth orbital, planetary, and Shuttle programs. In combination, these missions demand longer life, improved accuracy, lower weight, less power, and greater cost effectiveness. This program contributes directly to NASA's RE major technology thrust so that by 1990 spacecraft system costs will be significantly reduced through developments of 'standardized configuration-insensitive' control systems. Specific Program targets are: (1) by early TR76, complete development of flex body control analysis technology for predicting induced angular rates of planetary science instruments to better than 1 sec/sec; (2) by mid FY-77, mechanize and test a breadboard programmmable attitude control electronics with fault tolerant capability with a life potential of greater than 8 years; (3) by end of FY-77, develop and demonstrate an advanced breadboard model Star Tracker for Economical Long Life Attitude Reference (STELLAR) with a cost saving 50 percent (i.e., 1,200k reduced to 500k) of a typical Mars orbiter program; (4) derive and demonstrate a final design by early FY-78 of control filters and state estimation algorithms to meet science pointing requirements for rate settling to 2 sec/sec in less than 10 seconds; (5) by early FY-78, demonstrate an engineering model Long Life Reaction Wheel concept with life potential greater than 8 years; and (6) by FY-79, mechanize and test a breadboard Extended Life Attitude Control System (ELACS) with a 0.01 pointing accuracy and a lifetime potential of more than 8 years with functional redundancy.

**W77-70312** **506-19-15**
Ames Research Center, Moffett Field, Calif.
**VIDEO INERTIAL POINTING SYSTEM FOR SHUTTLE ASTRONOMY PAYLOADS**
D. R. Chapman 415-965-5065
(506-19-14; 356-41-06)

The objective of this RTOP is to develop and demonstrate an attitude reference system for shuttle-attached payloads that will substantially improve the rapid acquisition of targets, greatly enhance the flexibility and performance of the pointing control system, and enable driftfree astronomical observations without the use of multiple star trackers or on-axis guide stars. The Video Inertial Pointing (VIP) System utilizes a single solid state video star tracker and a microprocessor to generate three-axis pointing and stabilization signals. A cathode ray tube (CRT) display

and a three-axis joystick controller, coupled directly to the VIP microprocessor, provide the unique advantages of rapid target identification and precise instrument positioning by the operator. VIP is directly applicable to the Shuttle Infrared Telescope Facility (SIRTF), portions of the Atmosphere, Magnetosphere, and Plasmas in Space (AMPS) payload, and utility instrument mounts, such as the Small Instrument Pointing System (SIPS). VIP operates by using the position information generated by tracking multiple stars to update the instrument gyrostabilization system. The video sensor can track as many as ten stars simultaneously, permitting three-axis control with a single sensor. VIP will be developed utilizing a hybrid simulation and the existing AIROscope gyrostabilization hardware as system test elements.

**W77-70313** **506-19-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GUIDANCE AND NAVIGATION FOR UNMANNED PLANETARY VEHICLES**
R. V. Powell 213-354-6528
(186-68-54; 186-68-74; 186-68-85)

Long range goals (1986 and beyond) of this RTOP are: a ten-fold increase in data acquisition capability through improved navigation systems which maximize data gathering opportunities and minimize trajectory correction propellant requirements to increase usable science payload; and a ten-fold decrease in mission support costs through autonomous navigation and guidance which significantly reduces the need for ground station support. This will be attained by development of advanced navigation techniques incorporating new ground and on-board measurements and software in a space navigation system which enables efficient gravity assists, permits precise scientific observations, improves field of view delivery capability and enables mission opportunities. Goals will be achieved through the orderly development of measurement, orbit determination, maneuver strategy and maneuver execution subsystem technologies. Primary focus is on the development of the technology for an autonomous on-board guidance and navigation system (AG&N) required where the round-trip communication time exceeds the reaction time (interval between last navigation measurement and thrust or instrument pointing maneuver) or periods of communiction blackout (occultation or radio/tracking system anomaly). Concomitantly, estimation, performance prediction and maneuver strategy technologies developments will be completed to achieve maximum ground-based navigation system performance. Satellite system dynamics model development allows realization of the full potential of on-board optical navigation measurements for both the ground-based and AG&N systems. Demonstrations of new navigation technology will be carried out on on-going flight projects as opportunities arise. During FY-77 demonstrations of error reduction through utilizing multi-frequency and multi-station radiometric data will be completed on the Viking Mars mission. Subsequent targets include: maneuver strategy technology software for satellite gravity assist orbit control by FY-78, laboratory demonstration of an AG&N breadboard by FY-80, and by FY-86, design and validation in flight of a fully autonomous system capable of on-board flight path control to 1 km within two minutes of final measurement for small body rendezvous or flyby.

**W77-70314** **506-19-32**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ARTIFICIAL INTELLIGENCE FOR INTEGRATED ROBOT SYSTEMS**
R. V. Powell 213-354-6586
(970-23-20; 970-53-20; 970-63-20; 970-83-20; 506-20-11)

The long-range objective is to develop techniques for semiautonomous control of unmanned spacecraft to support lunar and planetary exploration. Spacecraft designed around such principles will require less frequent human intervention for their operation; the amount of data transmitted over the downlink channel for control purposes will be significantly reduced; fewer people will be required to support missions operations on Earth. The results will thus directly support the NASA goals of increasing scientific return by a factor of 1,000 and reducing mission costs by a factor of 10. There are numerous potential applications of the work inside and outside the space program. The approach at JPL is to produce robot hardware and software that can demonstrate performance in realistic environments. A roving vehicle has been built and placed under computer control, and its development as an integrated robot system has begun. During the remainder of FY76 and TR, coordinated action of the four basic rover functions (control, locomotion, manipulation, and vision) will be achieved in a simple indoor environment. Modifications to be completed toward the end of FY77 will enable the vehicle to be moved to a constrained but realistic outdoor environment. From experiments with alternate ways of conducting basic tasks, the best strategies for use of the hardware subsystems will be selected and improved. The rover will be reconfigured for removal of the umbilical cables between the real-time computer and the vehicle, leading toward installation of a radio link in FY78. Specific objectives for FY77 include incorporating semantic analysis of vision data for determining traversability of a region by the vehicle, improving the ability of the manipulator to operate safely in an imprecisely defined environment, and adding failure detection and recovery capabilities. In FY78, a radio link will be installed, a second manipulator added, and operation with a time delay demonstrated. In FY79, the rover will be operated in a natural environment like the Arroyo Seco near JPL, and spacecraft design and mission-operations guidelines will be prepared.

**W77-70315** **506-20-11**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ADVANCED DIGITAL DATA SYSTEMS FOR DEEP SPACE**
R. V. Powell 213-354-6586

The goal of this work is the development of advanced technology for integrated spacecraft data systems including the functions of control, data acquisition, data processing, and data storage. This work supports the NASA goals for achieving a 1,000X increase in space information systems capacity and reduction in cost by a factor of ten. The proposed work is focused on unifying the spacecraft data system functions and achieving an increased on-board data processing capability. Work during FY-77 will focus on continued development of a Unified Data System (UDS), for missions having launches after 1980. A specific UDS design was achieved in FY-75, and a UDS breadboard was fabricated and tested and associated software developed in FY-76. The effort encompasses the consolidation of hardware, the application of microprocessors, simplification of software, and incorporation of fault tolerance. The justification of a new UDS design is based on a cost savings goal of approximately $1,300K per mission for the mission set listed in 15.B of this plan. The $1,300K per mission saving represents $500K saving in flight software costs, $400K saving in support equipment and support software costs, and $400K saving in hardware costs due to the common processor and standardized S/C interfaces. Research will continue on tasks pertaining to improvement of space information system technology. The main emphasis during FY-77 will be directed to developing improved methods of handling high rate instrument data (imaging radar and multispectral imaging) for space missions in the 1980's. The work will include development of algorithms and implementation technology to accomplish on-board data reduction, data compression, and feature extraction. The objective is to increase space information system capacity while reducing costs.

**W77-70316** **506-20-13**
Marshall Space Flight Center, Huntsville, Ala.
**HIGH CAPACITY DATA SYSTEMS**
G. A. Bailey 205-872-1596
(502-23-31)

The long range objective of this RTOP is to produce a 10 to the 13th power to 10 to the 15th power bit Optical Archival memory. This memory is intended to replace the use of magnetic tapes used in archival storage facilities of large data base centers. The data that is stored archivally should be recorded on a medium that is permanent, has low cost per bit, can be recalled without reducing data quality, can be duplicated easily, and requires no maintenance. Magnetic tape has been used almost exclusively to date for archival storage of data. Yet, it has few of the desired characteristics. Data will, however, be provided to users on conventional mag tape compatible with their respective tape

readers. The key elements of an optical archival storage system are a laser, a page composer with suitable lateral position control, a multiple lens rotating scanner, film with axial or focus control, film transport system, and photodetector array. These elements are combined with suitable optics, drive electronics, and an opto-mechanical structure to provide a functioning system. Ideally, the system would be able to record at downlink rates approximately 350Mb/s), develop the recording medium with a dry process in real or near real-time and provide verification in soft or hard copy. There are several primary milestones necessary to achieve a cost effective and operationally successful system. The first will be a breadboard system capable of recording multiple channel data recorded at packing densities in the 1,000,000 to 10,000,000 bit/sq cm range at equivalent data rates of 1 - 10 Mb/s.

**W77-70317** **506-20-14**
Goddard Space Flight Center, Greenbelt, Md.
**AUTOMATED DATA HANDLING TECHNIQUES AND COMPONENTS**
David H. Schaefer 301-982-5184

The focus of this RTOP is to develop hardware especially suited for very high speed analysis of data in the form of images. Such hardware is especially needed for analysis of images generated by Earth Observation and other image sensing spacecraft. The approach is to develop parallel image processing systems. In particular, this RTOP is developing digital computer systems that perform between sixteen thousand and one million operations simultaneously. Very high effective processing rates will result from such massive parallelism. Massively parallel devices that use light as the method of information transfer from one device to another are being developed along with devices that utilize electrons as the means of parallel information transfer. During FY 77 technologies involving light that are in an early stage of development will be further developed. Work will be initiated on devices utilizing electrons as the information transfer mechanism. The expected product at the conclusion of this task will be the demonstration of computing systems that contain components operating at 10 to the 12th power bits per second. Such systems will be about four orders of magnitude faster than today's fastest digital computer systems. Real time processing systems that utilize coherent optical phenomena are also being developed.

**W77-70318** **506-20-22**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**MICROWAVE COMPONENTS AND TECHNIQUES**
R. V. Powell 213-354-6586

The general objectives of this RTOP have been established in accord with the NASA/JPL needs for future data transfer technology. Justification for the research program outlined in this RTOP is derived from the extensive reviews that have been conducted with respect to NASA-wide coordination and planning of technology requirements and thrusts. The 'Space Electronics Technology Study, "Outlook for Space Study,' and the "Communications Technology Enablement Study,' form the basis for the specific Objectives and Approach. Meeting the requirements and mission objectives of future spacecraft programs, long life, and decreased costs, continue to be prime goals. Standardization of communication hardware for all NASA spacecraft has become an important reality, requiring that the work be carried out with multimission spacecraft applications as an objective. Research is to be conducted on six fundamental data transfer technologies: (1) Digital Radio Systems, (2) Electronic Antenna Pointing, (3) Advanced Antenna Techniques, (4) Propagation Modeling, (5) Information Processing (coding), and (6) Coherent Relay Systems. The general approach taken consists of analysis, simulation, breadboards, and verification testing. In some cases, especially for digital radio and electronic antenna pointing, prototype hardware will be built and evaluated by outside contractors. The results will be in the form of documentation and recommendations to future flight programs, and the development of standard flight hardware.

**W77-70319** **506-20-23**
Lewis Research Center, Cleveland, Ohio.
**MICROWAVE AMPLIFIER TECHNOLOGY**
R. E. Alexovich 216-433-4000
(650-40-10)

The objective is to advance the state-of-the-art of microwave power amplification for space and terrestrial applications above one GHz. To achieve this objective, research and technology development programs will be undertaken on microwave amplifiers, high current density electron emitters and high power microwave passive components. Studies and investigations of space-Earth propagation and interference will be undertaken to guide high power communication component and subsystem investigation. Specific techniques such as multistage depressed beam collection and beam refocusing for linear amplifiers are among promising techniques being investigated in addition to rf circuit and electron gun optimization studies.

**W77-70320** **506-20-24**
Goddard Space Flight Center, Greenbelt, Md.
**MICROWAVE NEAR EARTH DATA TRANSFER AND TRACKING**
D. Santarpia 301-982-4158

The objective of the work under this RTOP is to achieve technological advances in data transfer and tracking systems in order to satisfy the demanding communication requirements for future space flight projects, such as Space Shuttle, Landsat Followon and TDRSS. The capability and performance requirements on the communication links for these advanced projects are characterized by high data rates (up to 240 Mb/s), simultaneous multi-link operation, and reliable long life operation. The attainment of these parameters shall be achieved through technical advances in Spacecraft techniques and hardware.

**W77-70321** **506-20-26**
Goddard Space Flight Center, Greenbelt, Md.
**MILLIMETER WAVE COMPONENT DEVELOPMENT**
J. L. King 301-982-5702

The objective is to develop millimeter wave component technology in the 50-200 GHz frequency range for use in advanced communications and microwave sensor systems. Plans for this program are divided into three areas: (1) Components and Techniques Development, (2) System Development, and (3) Propagation Experiments. Components and techniques in the 90 and 180 GHz frequency bands will be developed to improve the performance and reliability of the mixers and local oscillators required in the radiometric and communication receiving systems. These components will continue to be utilized to upgrade the performance of the 183 GHz sun tracking radiometer and 94 GHz point-to-point propagation links used to measure atmospheric losses from rain, snow, fog, etc. A 50 milliwatt solid state 92 GHz source will be developed to eliminate the need for the klystrons now being used. A cavity coupled rectangular waveguide type and a quasi-optical polarized grid type mixer design are now being constructed. Gallium arsenide schottky barrier materials from various sources will be evaluated in each of the mounts and conversion losses tabulated. Breadboards of completed 94 and 183 GHz solid state local oscillators waveguide cavity coupled mixers expect to achieve 7 db conversion losses at 180 GHz and 5 db at 94 GHz. The quasi-optical types should achieve similar conversion losses, but local oscillator coupling losses should be approximately equal to .3 db as versus 6 db for the waveguide types.

**W77-70322** **506-20-32**
Goddard Space Flight Center, Greenbelt, Md.
**OPTICAL DATA TRANSFER SYSTEMS**
J. H. McElroy 301-982-4942

NASA flight missions in the 1980's and 1990's will need high capacity data transfer systems. This RTOP is for the development of the technology to provide 300 Mbps and above data transfer terminals for space-to-space-to-ground relay links. The CO2 laser offers the best promise to meet these requirements, and laser heterodyne systems using this laser are being developed under this RTOP. Theoretical, analytical, and trade-off studies are conducted to establish system parameters. Research and development is carried out to advance the state-of-the-art critical components such as waveguide lasers, infrared mixers, modulators,

modulator drivers, and current regulated high-voltage power supplies needed for the laser discharge tubes. Acquisition and tracking techniques are being developed for spacecraft terminals. First-of-a-kind subsystems are assembled into engineering models in spacecraft configuration. Systems are evaluated in the laboratory and in test chambers to determine system performance parameters, such as bit error probability, receiver sensitivity, laser stability, and tracking errors (spatial and frequency). The research under this program will culminate in an early Space Shuttle to ground laser communication experiment. This RTOP also includes NASA's support for basic university research in laser physics by distinguished scientists.

**W77-70323** **506-20-33**
Goddard Space Flight Center, Greenbelt, Md.
**GEOPHYSICAL MEASUREMENT TECHNOLOGY**
M. W. Fitzmaurice 301-982-4948
(161-02-01; 653-01-01)

This RTOP is to provide the technology necessary for the development of precise spaceborne and ground-based laser ranging systems. Specific objectives are: (1) to develop the component and subsystem technology to advance the state-of-the-art in ground based laser ranging systems from the 5 cm level in FY 76 to the 2 cm level in 1978, and (2) to develop the flight qualifed components for a spaceborne laser system with 5-10 cm range accuracy. This spaceborne terminal is to be tested at the engineering model level in 1979 and will lead to a flight test on a 1980-81 Shuttle mission. This RTOP interacts closely with RTOP's 161-02-01 and 653-10-01 in the development of ground-based systems and interacts closely with 645-40-01 in the development of the spaceborne systems. The three major tasks within this RTOP are: (1) advanced receiver development, (2) flight qualified Nd:YAG laser development, and (3) precision tracking and control systems development.

**W77-70324** **506-21-10**
Lewis Research Center, Cleveland, Ohio.
**ADVANCED LIQUID ROCKET COMPONENT TECHNOLOGY**
D. A. Petrash 216-433-4000

The general objectives of the programs conducted under this RTOP are to provide the technology for improvements in performance and reusability of liquid rocket components and subsystems. Experimental and analytical programs will be conducted to develop: (1) low cycle thermal fatigue and heat transfer technology for reusable thrust chambers, (2) advanced thrust chamber technology using unconventional nozzles, (3) improved fabrication techniques for thrust chambers, and (4) reduced gravity fluid acquisition and transfer systems. In the area of reusable thrust chamber technology, efforts will be devoted to testing materials and new designs in an inexpensive thrust chamber simulator and correlating the results with the analytical capability to predict life that was previously developed. Advanced heat transfer techniques will also be applied to ease the severity of the thermal load of high performance thrust chambers, and improved fabrication techniques involving sputtering and electroforming will be evaluated to produce lighter, more reliable thrust chamber hardware. Unconventional nozzles will be investigated to provide more flexible design options, low pressure solutions to advanced engines, and high area ratio, high performance thrust chambers in a minimum size envelope. Low gravity fluid system studies will investigate critical characteristics and components for in-orbit fluid acquisition and transfer.

**W77-70325** **506-21-11**
Lewis Research Center, Cleveland, Ohio.
**ADVANCED LIQUID ROCKET SYSTEMS TECHNOLOGY**
John W. Gregory 213-433-4000
(506-21-12; 910-03-01; 790-40-12)

Analytical and experimental efforts are being pursued to provide technology required for: (1) advanced high pressure reusable low thrust engine for advanced Orbit Transfer Vehicle (OTV) main propulsion system application; (2) advanced high pressure reusable large thrust engines for Earth-to-Orbit (ETO) vehicle application; and (3) hydrogen-oxygen integrated auxiliary propulsion system for an advanced OTV. In the low thrust engine area, the effort is directed at developing the technology for a hydrogen-oxygen pump-fed staged combustion cycle bell nozzle engine and a hydrogen oxygen pump-fed, expander cycle aerospike nozzle engine. The work for the staged combustion cycle engine is concentrating upon critical component technology for a 20,000 pound thrust engine operating at a chamber pressure of 2,000 psia. The component technology programs are in the turbo machinery and thrust chamber areas. In the aerospike engine area, a 25,000 pound thrust chamber has been fabricated and will be tested to determine its Isp performance, regenerative cooling capability, and structural integrity. If the FY78 new initiative is approved, the components developed in the technology programs will be used to build breadboard engine assemblies. Tests will be made to assess component adequacy, capability, interactions and operating characteristics. In the large thrust size booster engine area, work will be initiated in several areas.

**W77-70326** **506-21-12**
Lewis Research Center, Cleveland, Ohio.
**REUSABLE CRYOGENIC STORAGE**
John W. Gregory 216-433-4000

The work conducted under this RTOP will provide the technology required for the effective design and fabrication of reusable cryogenic thermal protection systems for ground based and space based vehicles. This work will be conducted on thermal protection systems designed to meet the problems associated with the changing environments experienced during a typical flight cycle by reusable high energy vehicles. Work on a purged multilayer insulation system will be continued. Experimental evaluations will be conducted on several baseline multilayer insulation systems to evaluate their performance under cyclic environmental conditions. Work will continue on a high performance load bearing insulation that is capable of providing performance approaching that of uncompressed MLI while still providing all of the advantages of an evacuated system without the attendant weight penalty usually associated with rigid vacuum shells.

**W77-70327** **506-21-21**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**LONG LIFE ADVANCED PROPULSION SYSTEMS FOR PLANETARY SPACECRAFT**
P. J. Meeks 213-354-2546
(525-71-21; 506-21-51)

The objective of this RTOP is to provide the advanced development of key liquid feed-assembly components, and of the rocket engine assembly, for advanced liquid propulsion systems for use on planetary missions. The first portion of this effort will be devoted to the support of an on-going effort to develop a durable fluorine/hydrazine engine. The work will involve both an on-going in-house effort and continued contractual effort in design and fabrication of preprototype and prototype engines. The three-phase contract, started in FY76 will continue into FY78. The second portion of this effort will support on-going liquid-fluorine components work, specifically: continuation of long term materials compatibility testing; fabrication of a service/emergency dump valve; purchasing a prototype fluorine isolation valve; design of a fluorine relief valve; reactivation of a components test flow bench; and acceptance testing of prototype propellant shutoff and isolation valves.

**W77-70328** **506-21-32**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ADVANCED SOLID PROPULSION AND PYROTECHNIC CONCEPTS**
P. J. Meeks 213-354-2546
(506-21-52)

The objective of this work is to introduce and demonstrate solid propellant rocket and pyrotechnic advanced technology which will (a) reduce cost, improve performance, flexibility, and reliability of existing designs, and (b) provide new concepts for NASA missions in the 1980-2000 period where enabling technology in solid propulsion and pyrotechnics is needed. The applications of this technology advancement are NASA launch vehicles and spacecraft for planetary, orbital, landing and take-off propulsive maneuvers. The approach to the work will be comprehensive

and will utilize theoretical, analytical and experimental investigations in the process of selection, development and demonstration of advanced technologies. Both in-house and subcontracted modes will be used in the conduct of the work. Some effort will be expended in providing solutions to existing solid motor and pyrotechnic design and operational problems. This plan constitutes the major element of the OAST Level IV Program on 'Low Cost Solid Propulsion.' The specific tasks included in this RTOP are: (a) Advanced Upper Stage Motor Technology; (b) Heat Sterilizable Propellants; (c) Long Term Storage of Solid Propellants in Space; (d) Class 2 Stop-Restart Propellant; (e) Mixed Oxidizer Propellants; (f) Microbial Production of Perchlorate; (g) Pyro and Explosive Technology; (h) High Back Pressure Propulsion; (i) Laser-Explosive Interaction; (j) Solid Propellant Combustion; and (k) the Caltech Combustion Study.

**W77-70329** **506-21-40**
Lewis Research Center, Cleveland, Ohio.
**LASER PROPULSION TECHNOLOGY**
D. J. Connolley 216-433-4000

The objective of this program is to evaluate the concepts and establish the potential feasibility of laser propulsion by 1980. The program will investigate propulsion concepts and systems based upon the energy being transmitted by a laser beam from a remote station. Space, aircraft and earth-based laser systems for potential NASA and military application will be included. A broad technology base will be developed for realistic appraisal of systems, mission application and design. Efforts will concentrate on most appropriate laser systems, beam transmission, laser-beam receiver systems, efficient conversion of laser beam energy to sensible propellant enthalpy, and viable thruster design. The program approach includes: (a) identification of laser energy absorption mechanisms in propellants; (b) performance of components and systems studies (synthesis, definition, design, tradeoffs, and problem area identification); (c) evaluation of potential mission possibilities; (d) design, fabrication and evaluation of laser thruster concepts; and (e) investigation of optimum wavelengths and lasers for propagation, absorption by propellant and compatibility of optics systems.

**W77-70330** **506-21-41**
Lewis Research Center, Cleveland, Ohio.
**ATOMIC AND METALLIC HYDROGEN**
Gerald V. Brown 216-433-4000

The objectives are to produce and store hydrogen in each of two different monatomic forms, metallic hydrogen and spin-aligned atomic hydrogen. Either form would store an energy of approximately 50 K cal/gram with respect to the molecular state. Such stored energy would be recoverable by allowing reversion to the molecular state: to investigate superconductivity of metallic hydrogen; to determine other properties of both new allotropes; and to study H-H2 mixtures. High pressure devices capable of producing a few megabars will be developed to compress hydrogen to about 15 times the ordinary molecular solid density and thus cause the predicted transition to the metallic state. Hydrogen dissociated to atoms by various means (electric discharge, photolysis, and irradiation) will be stored at temperatures below 2 K and in magnetic fields of 2 to 10 tesla to paramagnetically align the electron spins and prevent formation of the molecular bond. Matrix storage of H in H2 will be investigated to determine maximum H concentration possible as a function of temperature (below 2 K) and magnetic field.

**W77-70331** **506-21-42**
Langley Research Center, Langley Station, Va.
**HIGH PRESSURE GAS LASERS IN SPACE**
P. F. Holloway 804-827-2893
(506-25-32; 506-18-12)

The objective is to develop new photopreionized high pressure, high energy density gas lasers, capable of continuous tuning across pressure broadened overlapping laser lines and of simultaneous multiline operation with high frequency stability of approximately 10 MHz. Continuous tunability will be achieved through a combination of high pressure operation and use of gas mixtures for increasing the number of laser lines. The lasers will operate at pulse energies in excess of 1 Joule at low repetition rate, and at lower pulse energies up to 10,000 pulses per second. Stable continuous tuning will be evaluated for two-laser oscillator types, in an oscillator amplifier configuration. One will be a travelling wave ring laser configuration, the other a laser with small cross-section, but larger than that of a waveguide laser, which has limitations in pressure and tunability. Laser scaling laws will be evaluated to satisfy future needs for remote interaction of laser radiation with other media.

**W77-70332** **506-21-43**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**NEW HORIZONS IN PROPULSION**
P. J. Meeks 213-354-2546

The objective of this program is to identify and assess the feasibility of new concepts in propulsion which offer significant improvements over systems which now exist or which presently are in a state of advanced development. The approach is to define the concepts in sufficient detail to allow initial applications analyses to be made and then to evaluate the applications. These concepts are compared with current systems and with each other. Experimental and theoretical investigations then are conducted as required for verification of those concepts which are promising. Studies which will be conducted include: (1) the production and storage of antimatter and the control of matter-antimatter annihilation, (2) methods of 'tapping' energy available in space - for example, energy which may be obtainable from the interaction between a fluctuating magnetic field located in the vicinity of a planet and an electrically conducting fluid in turbulent motion aboard the spacecraft, (3) analysis of the use of indigenous materials such as moon rocks for propulsion, power, and other applications, (4) the utilization of planetary atmospheres, (5) efficient physical processes for converting high-energy-density sources into directed kinetic energy for producing thrust or into electrical energy for power generation, and (6) system definition and system performance projections for the use of metallic hydrogen and excited helium.

**W77-70333** **506-21-44**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GENERATION AND STORAGE OF ACTIVATED SPECIES**
P. J. Meeks 213-354-2546
(506-21-43)

The Main objective of this RTOP is to investigate novel and promising approaches for storing energy in excited atomic and molecular species and in highly compressed materials for propulsion and other applications. To achieve this objective, experimental and theoretical investigations will be made to: (1) devise methods of producing and increasing the lifetime of excited states of helium and other atomic and molecular species in both liquid (superfluid and normal) and solid phases of helium; (2) produce and stabilize solid materials containing very high concentrations of hydrogen/deuterium; and (3) produce and stabilize solids which have undergone electronic collapse.

**W77-70334** **506-21-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SPACECRAFT LIQUID PROPULSION RESEARCH**
Paul J. Meeks 213-354-2546
(506-21-21)

The injection, ignition, combustion, and wall compatibility characteristics of those propellant combinations suitable for spacecraft propulsion systems are being studied both experimentally and analytically. The objective is to provide fundamental understanding of the interacting chemical processes that are essential to the development of a technology base that forms a precursor to the application of high performance, reliable and predictable propulsion systems to unmanned space exploration missions. The relevant technical activities include: (a) correlation of experimental measurements of mass and mixture ratio distributions in rocket engines with non-reactive spray properties and analytical predictions; and (b) the formulation of an analytic representation (computer model) of a rocket combustor which predicts performance in terms of specific impulse and chamber life-times and (integrity in their completed configuration the input parameters for such representations will be limited to those quantities, such as dimensions and assigned flows, that are known

a priori); (c) computer modeling of experimental measurements of deposition on spacecraft surfaces due to the backflow of rocket nozzle plumes in deep vacuum; (d) the development of a Monopropellant Performance Standardization Handbook which will recommend methodology to be used in the acquisition, reduction, and reporting of monopropellant rocket engine test data; (e) identification and comparisons of means for obtaining cruise mode propulsion and ancilliary lift in the Jovian atmosphere; and (f) analytical comparisons of the performance of a high pressure (1,000 psia) earth storable, N2H4/Borane propellant combination with its competing space storable system (F2/N2H4).

**W77-70335** **506-21-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SOLID PROPELLANT RESEARCH**
P. J. Meeks 213-354-2546
(506-21-32)

The objective of this RTOP is to establish scientific bases for the chemical formulation, mechanical design, and surveillance of solid propellants for rocket motors. Theoretical and experimental investigations will be performed in rheology, network structure, ingredient synthesis and purification, and curing and degradation chemistry to obtain a better understanding of propellant mechanical properties, processing and environmental stability characteristics to permit the formulation of techniques for the control thereof and to derive information which will enable one to design motors as structurally integrated units with a minimum of empirical study and to predict their useful lifetimes on the basis of expected environmental duty cycles.

**W77-70336** **506-21-53**
Lewis Research Center, Cleveland, Ohio.
**PHYSICS AND CHEMISTRY OF CHEMICAL PROPULSION**
D. A. Petrash 216-433-4000

The objective of this work is to expand the basic understanding of injection, mixing, combustion, and other chemical and physical processes in chemical propulsion systems in order to provide higher performing, more reliable, and lower cost systems for future missions. This objective will be attained through theoretical studies to delineate the important design parameters required to achieve engineering improvements, experimental studies to demonstrate the validity of specific theoretical approaches and design parameters, and exploratory studies to investigate new techniques or theoretical approaches that will provide further engineering improvements in liquid rocket engines. Areas in which this effort will be applied are combustion, fluid flow, and thermodynamic, transport and kinetic data.

**W77-70337** **506-21-54**
Lewis Research Center, Cleveland, Ohio.
**SPACE SAFETY RESEARCH**
Donald A. Petrash 216-433-4000

The objectives are to obtain a better understanding of the hazards and improve the safety of NASA and contractor operations associated with oxidizer and fuel systems and related propellants for flight, R and D facilities, and ground service equipment. Specific areas of current interest include: preparation of criteria for the design and operation of propellant systems, investigations of combustion and non-ideal explosions caused by propellant spills and tank ruptures, and techniques for predicting vessel fragmentation effects. Additional activities are concerned with spacecraft fire technology and include the analysis and tests of gravity effects on fire extinguishment systems, the demonstration of an effective fire extinguishment system in spacecraft environments and toxicity related studies including the analysis of gaseous emissions of spacecraft materials under fire, and toxicity studies of propellants and fire extinguishing agents.

**W77-70338** **506-21-55**
Marshall Space Flight Center, Huntsville, Ala.
**BOUNDARY LAYER INTEGRAL MATRIX PROCEDURE**
K. W. Gross 205-872-0686
(506-21-65)

The boundary layer computer program, currently used to evaluate and predict friction losses and heat transfer, uses analytical formulation derived from cold flow experiments. Good agreement between predictions and test data for various flow conditions has been obtained except for large temperature ratios across the boundary layer due to the lack of test data. To verify the computer program prediction reliability for this condition a test program will be conducted to establish a data base. Test hardware will be developed and equipped with the required instrumentation to obtain the significant measurements used in the prediction verification process. If necessary, analytical formulations will be modified and incorporated into the computer program.

**W77-70339** **506-22-11**
Lewis Research Center, Cleveland, Ohio.
**AUXILIARY PROPULSION ION THRUSTER TECHNOLOGY**
R. C. Finke 216-433-4000

The general objective of this program is to advance the state-of-the-art of electron bombardment thruster systems through applied research and development on thruster systems with thrust levels from a fraction of a millipound up to 10 millipounds and power levels from a fraction of a kilowatt to 1 kilowatt. Specific objectives contributing to the general objective are to transfer basic research results into potentially useful thrusters and thruster systems, to provide the technology to extrapolate mercury ion thruster performance at larger or smaller thrust levels and to develop prototypical 1-millipound mercury ion thruster system hardware and subject it to flight qualification level testing. The approach in general is to use information from previous and ongoing basic research and incorporate it into new components and thruster configurations. Successful components and configurations are then integrated into thruster systems and evaluated. A further step is to verify the efficiency and durability of thruster systems designed to meet a typical flight mission requirement. The work will be performed both by in-house and contracted efforts.

**W77-70340** **506-22-30**
Lewis Research Center, Cleveland, Ohio.
**PRIME PROPULSION ION THRUSTER TECHNOLOGY**
R. C. Finke 216-433-4000

The overall program goal is to identify and develop the required technology to demonstrate technology readiness status for primary propulsion subsystems for proposed missions. Development and testing of thrusters, power processors, and interface elements will be done to optimize element performance, lifetime, and reliability and also define and characterize the critical system interfaces and requirements. The program will result in a baseline technology and design criteria for application to anticipated electric propulsion spacecraft. The approach is to define requirements, develop to engineering model status, and verify by life tests and multiple thruster operation, primary propulsion thrusters which satisfy the range of requirements of foreseeable missions. Power processors will be designed and developed to functional model status, integrated with thrusters, and verified by system level and lifetime testing. Other critical system elements such as gimbals, propellant storage and distribution system, and thrust subsystem-spacecraft interface hardware and software will be simulated and integrated into a functional subsystem. Thrust subsystem interactions and integration problems will be investigated to the extent necessary to clearly define critical interfaces and system requirements and reduce risk in future applications. The program will be carried out via both in-house and contracted programs.

**W77-70341** **506-22-32**
Marshall Space Flight Center, Huntsville, Ala.
**SOLAR ARRAY TECHNOLOGY FOR SOLAR ELECTRIC PROPULSION (SEP) AND PAYLOAD APPLICATIONS**
L. E. Young 205-872-2110

The objective of this RTOP is to insure the availability of solar array technology which meets solar electric propulsion requirements. The approach is to perform a preliminary design in order to identify the solar array technology required to support solar electric propulsion. This technology will be compared with the state-of-the-art to identify areas where demonstration of further development of technology is needed. These areas will be worked as specific tasks with results being fed back into the

design effort. The availability of overall array technology will be demonstrated by fabricating and testing a full-scale wing. To accomplish the objective, the following tasks will be performed: (Task 1 was completed in Dec. 1974); (1) Task 1: Preliminary Design for Identification of Required Technology, (2) Task 2: Materials Demonstration, (3) Task 3: Thermo-compression Bonding of Solar Cells to Electrical Interconnects, (4) Task 4: Solar Cell Selection and Characterization, (5) Task 5: Solar Cell Module Thermal Cycling, (6) Task 6: Non-Destructive Inspection and Tests, and (7) Task 7: Full-Scale Wing Technology Demonstration.

**W77-70342** **506-22-33**
Marshall Space Flight Center, Huntsville, Ala.
**SEPS ENVIRONMENTAL IMPACT**
J. B. Stephens 205-872-2114
(180-17-56)

This RTOP is for the investigation of the parametric qualities associated with terrestrial perturbations in the lower stratosphere and the troposphere from the release of mercury. The study contract for RTOP 180-17-57 on the Environment Impact of Solar Electric Propulsion revealed that a detailed analysis of the effects of a mercury release from a failure mode in these regions of the atmosphere required additional definitive investigation to establish reaction rates and diffusion parameters. This work will address the following tasks: (1) complete the work on the reactions and rates of mercury to determine the long term effects of mercury in the lower stratosphere, (2) using the mathematical model for the deposition and diffusion of mercury in the troposphere, assess the transport of a mercury release in the troposphere, and (3) preparation of a revised environmental assessment for electric propulsion based on the above.

**W77-70343** **506-22-40**
Lewis Research Center, Cleveland, Ohio.
**ION THRUSTER RESEARCH**
R. C. Finke 216-433-4000

The objective of this work is to increase the knowledge of electron-bombardment ion thrusters in an orderly and meaningful manner. Basic physical processes are studied, both experimentally and analytically, for a range of thruster sizes commensurate with thrust levels of 2 to 500 millinewtons. Although mercury vapor is the chief propellant used, other propellant gases, such as argon and xenon are also studied for specific mission or ground-based applications. A further objective of this work is to define and understand interactions between ion thrusters and the spacecraft, mission and science payload. Experimental and analytical studies are conducted through grants, contracts and in-house programs. Specific programs include: (1) probing the plasma discharges of the thruster to identify reactions and support analytical theory, (2) developing analytical theory to predict thruster limitations and ultimate performance, (3) novel ways to improve thruster starting reliability, such as the use of a high voltage pulse to light the cathodes, (4) measurement and control of thruster efflux, both in the thruster and on spacecraft surfaces, and (5) experimental testing of novel thruster configurations to extend and improve performance with xenon, argon and other gaseous propellants.

**W77-70344** **506-22-43**
Lewis Research Center, Cleveland, Ohio.
**ION BEAM APPLICATIONS RESEARCH**
R. C. Finke 216-433-4000

The broad objective of the work described herein is to provide the basic research and technology needed to define and develop nonpropulsion applications of electrostatic accelerator technology. By conducting pertinent experimental and analytical studies, the overall program is directed at demonstrating fruitful application of the unique capabilities of electrostatic accelerator technology to the improvement of (1) Sputter deposition by ion beam, (2) Ion sources for fusion systems and applications to the Controlled Thermonuclear Reaction (CTR) program, (3) Ion milling and polishing, (4) Space manufacturing applications, and (5) Biomedical applications. Major programs are directed at identifying applications which could strongly benefit from the unique capabilities inherent in this technology. Specifically, the program goals are to identify manufacturing processes which could substantially benefit from the ability to clean and etch a substrate and deposit layers of virtually any material in a high vacuum environment, free from undesirable contaminants. Freedom to independently control substrate temperature may allow the material to be deposited in structure ranging from epitaxial to amorphous. Controlled impurity deposits and graded layers will be investigated. Large, high current, well-neutralized ion beams for injection into magnetic containment devices will be investigated. Other applications requiring the unique capabilities of this technology will be explored and investigated.

**W77-70345** **506-22-44**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PULSED MPD ARC JET WITH INDUCTIVE ENERGY STORAGE**
A. Briglio, Jr. 213-354-6137

The objective of this RTOP is to investigate and assess the feasibility of operating quasi-steady MPD arc jet thrusters directly from a nuclear thermionic power source through and inductive storage device. The magnetoplasmadynamic (MPD) arc jet is an electro-magnetic plasma thruster which operates from a low voltage (100-150 V) at high current (greater than 10,000 A). The self-inductance of this device at large current levels generates a desired magnetic field for propellant acceleration, increasing the propulsion efficiency. The thruster operates at lower average power by pulsing, where very large capacitors are presently used for energy storage. It now appears that inductive energy storage could lead to a more desirable system development than capacitive storage. The feasibility of this concept requires study,

**W77-70346** **506-23-12**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PLANETARY SOLAR POWER RESEARCH AND TECHNOLOGY**
A. Briglio, Jr. 213-354-6137

The OAST Space and Nuclear R&T Program and Specific Objectives Document, FY 1976, Level IV Specific Objective is 'to provide low-cost solar cells and arrays with high power density and high end-of-life efficiency (radiation resistance).' The JPL FY TR and FY 77 programs for planetary solar power and technology addressed to the stated objective are: (1) continue the development of thin high-efficiancy solar cells, (2) continue the lightweight solar array development with a goal of 200 W/Kg, (3) continue the testing and evaluation of solar cells for space applications, and (4) extend the automated module fabrication facility into a Phase II development. This work will be accomplished through combined in-house and contracted efforts with industry and universities.

**W77-70347** **506-23-17**
Lewis Research Center, Cleveland, Ohio.
**SOLAR CELL TECHNOLOGY**
D. T. Bernatowicz 216-433-4000

The objective of this RTOP is to develop the technology for low-cost solar cells and arrays with high end-of-life efficiency. Research and technology programs will be continued in the following areas: (1) research into the basic loss mechanisms and radiation damage in photovoltaic devices; (2) development of cells with improved end-of-life efficiency (such cells may include epitaxially-grown junction, ion implanted junction, back surface field, heavily doped base, wraparound contact, and textured front surface); (3) investigation of processes for fabricating cells at low cost, including thick film processes for contacts, interconnects, and coatings, nongaseous diffusion sources, and integration of automatable processes into a fabrication line; (4) exploratory development of new concepts for covering and (5) encapsulating solar cell modules with plastic sheets; and flight experiments to evaluate FEP-encapsulated solar cells and modules.

**W77-70348** **506-23-22**
Goddard Space Flight Center, Greenbelt, Md.
**BATTERY QUALITY CONTROL AND TEST**
Floyd E. Ford 301-982-6202

The objectives are to: develop an accelerated test technique for determining and predicting a battery's useful life, improve

the usable energy density of Nickel-Cadmium batteries without compromising life, maintain a NASA Test Facility for evaluating and life testing new technology as it becomes available, develop cell and cell component characterization methods for application to manufacturing process control, and develop analytical methods and techniques for analysis of cell components.

**W77-70349** **506-23-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ELECTROCHEMICAL ENERGY CONVERSION AND STORAGE**
A. Briglio, Jr. 213-354-6137

This RTOP is directed toward providing the battery technology to support future planetary missions and terrestrial applications. The objectives, in accord with the NASA Program Objectives, are to attain long-life (10 year), high-energy-density, and highly reliable low-cost electrochemical energy storage devices by advancing the technology of its components, operating and storage techniques, and test and evaluation procedures. Specific targets are: (1) to advance the state-of-the-art of nickel-cadmium technology by developing a cell capable of a 10-year life and an energy density of 55 wh/kg through innovative design technology and by establishing nickel-cadmium design and predictive models based on all available empirical data, and by improved operational techniques, (2) to develop primary batteries for planetary probe missions that can deliver high power outputs (15 C) after prolonged (7-10 years) storage, and (3) to develop advanced battery electronics, including modular sequential charging and pulse charging, thereby improving reliability and extending the lives of cells and batteries.

**W77-70350** **506-23-24**
Lewis Research Center, Cleveland, Ohio.
**ELECTROCHEMICAL ENERGY CONVERSION AND STORAGE**
J. Staurt Fordyce 216-433-4000

The object of this program is to attain long life, high energy densities and high reliability for electrochemical energy storage and conversion devices. The emphasis is on alkaline batteries and separators, electronic techniques for improving performance/life, H2-O2 fuel cells and exploratory studies on high energy density systems. During fiscal year 1977 the performance matrix for NASA-developed silver-zinc cells will be completed. Techniques to prolong the life of alkaline batteries will be explored further in particular, tests of the electronic single cell protector on a silver-zinc battery and preliminary work on the effects of charge/discharge pulsing will be completed. Work will continue on the silver-hydrogen battery with 5 times the energy density of nickel-cadmium for 10-year life in synchronous orbit. Parametric studies will be done to define technology for readiness for a broader systems technology effort in FY-78. The nickel-cadmium cell will be advanced towards a lighter weight, deeper depth capability cell. The effort is on lightweight electrodes and the introduction of advanced separators. The alkaline battery separator technology will advanced to fully exploit the inorganic concepts in various systems and provide low cost, mass producible materials. H2-O2 fuel cell technology will focus on adapting the lightweight hardware to inert-saturated reactants and a start will be made on a second-generation 1,000 asf, higher efficiency technology. The exploration of high energy density systems (150 watt-hr per lb., 100 C) continues, focussed on thin solid Na+ conductor and the soluble sulfur electrode.

**W77-70351** **506-23-30**
Lewis Research Center, Cleveland, Ohio.
**ADVANCED POWER PROCESSING AND DISTRIBUTION TECHNOLOGY**
P. A. Thollot 216-433-4000
(506-23-31)

The objectives of this program are to advance the state-of-the-art and establish the technology required to improve aerospace and terrestrial electric power processing and distribution systems. Addressed are improvements in electric circuit performance, development of advanced circuit concepts, and development of modeling and analysis techniques. In addition to this general technology, this program has, as further objectives, the development and use of integral solar array power regulation and directed technology for specific applications such as lightweight power processing for ion thrusters. The work under this program will be accomplished both by in-house and contract analytical studies and experimental investigations of breadboarded circuits and equipment. The program is directed toward simultaneously solving the technology needs of near-term high power and high voltage applications, while continuing with a long-term program toward achieving low cost and more effective power processing capabilities. A strong emphasis is placed on the achievement of common power processing design techniques, standardized circuitry, and analytical tools.

**W77-70352** **506-23-31**
Lewis Research Center, Cleveland, Ohio.
**HIGH PERFORMANCE POWER ELECTRONICS COMPONENTS**
P. A. Thollot 216-433-4000
(506-23-30)

The objectives of this program are to advance the state-of-the-art and establish the technology required to improve electronic power components and subsystems and to investigate interactions between the electrical systems and the environment of spacecraft. This includes the development of improved electronic power components as required for use in low weight, high efficiency power processors and distribution systems. It also inlcudes the effects of photoconductivity in space type electrical insulating materials at high voltages. Contractor and in-house experimentation and analysis will be used to continue development and/or testing of electrical components, such as high performance capacitors, improved power semiconductors, improved magnetic power devices, and solid state switchgear for dc systems above 100V. Also, investigations of interactions of high voltage with space environment will continue with emphasis on photoconductivity in dielectric materials.

**W77-70353** **506-23-32**
Goddard Space Flight Center, Greenbelt, Md.
**POWER PROCESSING FOR EARTH ORBITAL SPACE SCIENCE AND APPLICATIONS SATELLITES**
Edward R. Pasciutti 301-982-4885

This RTOP defines a program in power electronics utilizing university personnel and facilities. GSFC personnel involvement is limited to the extent of initiation, guidance and evaluation, plus, as warranted, a necessary amount of exploratory investigation, or advanced in-house design and development. The RTOP objectives are: to expand the power electronics technology base; to lower cost by both reducing development time and the achievement of commonality of designs; and to improve high voltage, circuit reliability through research of circuits, components, materials, potting and assembly techniques.

**W77-70354** **506-23-33**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**LONG-LIFE, HIGH-PERFORMANCE POWER PROCESSING FOR PLANETARY APPLICATIONS**
A. Briglio, Jr. 213-354-6137
(506-23-23)

The objective of this RTOP is to develop and demonstrate advanced power processing and distribution and related system configuration and integration technology to meet the requirements of future planetary spacecraft. These requirements, which are identified in NASA's 'Objectives Documentation,' include longer life, higher performance, higher reliability and lighter weight than is achieved with existing technology. The intent of this work is to develop designs that not only can accommodate technical needs but which can also be built and incorporated into the spacecraft power system for minimum cost. In developing the necessary capability, techniques and hardware it is required that the specialized requirements of both solar and sun-independent power sources be accommodated. The program comprises several related tasks and subtasks. First, modular designs for the major power processing elements (regulators, inverters, etc.) within the spacecraft power system are being developed. These designs are standardized to the maximum extent possible and feature active rather than standby redundancy. This minimizes

the total number of separate modules required in the system and, hence, the cost to build and test it. High-performance circuits are used throughout, and the basic approach offers a large degree of flexibility for scaling the system to different input voltages and power levels, thus providing capability for multiple applications. Second, electronic circuits needed to optimally charge, discharge, protect and control the spacecraft battery system are being studied and developed. This will help enhance battery performance and life. Third, technology and equipment that can be used to automate the test, analysis and qualification of multi-redundant power systems prior to launch is in development. In performing these tasks innovative, new design and analysis techniques are being developed and applied as well as utilization of newly available components such as microprocessors and hybrid microcircuits.

**W77-70355** **506-23-34**
Marshall Space Flight Center, Huntsville, Ala.
**MULTI-KW DC DISTRIBUTION SYSTEM TECHNOLOGY**
J. L. Felch 205-872-4634

The objective is to demonstrate the technology readiness and performance advantages of high voltage dc (HVDC) distribution and control systems for large manned aerospace vehicles. Additional objectives are to evaluate the merits of solid state switchgear and miltiplexed computer controlled supervision and control methods in conjunction with HVDC distribution. The approach is to provide overall demonstration of technology by testing a full scale distribution system utilizing voltages up to 300 Vdc and solid state switchgear. To accomplish these objectives, the following task will be performed: (1) Task 01- the design, fabrication and test operation of a flexible distribution system simulator at MSFC.

**W77-70356** **506-23-35**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**AUTOMATED POWER SYSTEMS MANAGEMENT**
A. Briglio, Jr. 213-354-6137

Future planetary spacecraft will have to perform for greater periods of time, more remotely from ground control in more hostile environments than their predecessors, and the missions will become more complex involving orbit changing and real-time adaptive sequence changes. These more demanding aspects of future missions establish unique requirements upon power system capability, reliability, and operation. System capability will be pressed by the wide variations of performance parameters which are dependent upon distance and mission duration. Reliability requirements will be determined by the need to perform for up to 10 years. Operationally the power system will accommodate real-time changes in mission execution and provide fault correction capability autonomously, because intervention from ground stations cannot occur in real-time. The work described in this RTOP is in accordance with the NASA Specific Objectives and Targets for Space Energy Systems R and T to achieve autonomous capability in planetary spacecraft power systems. Referred to as APSM, Automated Power Systems Management is the capability of a spacecraft power system to automatically perform monitoring, computational, command, and control functions without the need for ground intervention. The effort will include analysis, design development, and evaluation of hardware and software necessary to demonstrate the readiness of APSM technology in FY81. APSM technology will be developed for planetary class solar array and RTG powered systems, and battery powered systems. Technical emphasis will be with respect to defining the appropriate functions to be managed, sensor development, interface definition, software algorithms, and breadboard demonstrations using the latest available computer hardware.

**W77-70357** **506-23-36**
Lewis Research Center, Cleveland, Ohio.
**ENVIRONMENTAL CHARGING OF SPACECRAFT SURFACES**
R. R. Lovell 216-433-4000

The objectives of the work to be conducted are to investigate and define the space environment and the associated mechanism for spacecraft charging and discharging; to provide design criteria, and techniques to insure the control of both differential and absolute charging of spacecraft surfaces; and to evaluate designs for flight experiments to measure the charging phenomena in the space environment. To achieve these objectives, a comprehensive research and technology program on spacecraft charging will be undertaken. The program will consist of an analytical effort to model the environment and to investigate the charge/discharge mechanisms, and an experimental effort to evaluate the material response to the environmental flux and to study the behavior of large scale models of spacecraft and spacecraft systems in a simulated charging environment. The program will coordinate and supplement work being planned in this area by groups in industry, universities, and the DOD. The ultimate output of the program will be a spacecraft charging design monograph. This RTOP covers the NASA portion of the joint NASA/AF program on spacecraft charging investigation.

**W77-70358** **506-23-40**
Lewis Research Center, Cleveland, Ohio.
**THERMO-MECHANICAL ENERGY CONVERSION**
R. P. Migra 216-294-6862

The objective of this Rtop is to provide a technology base for high-efficiency, long-life, low-cost, thermo-mechanical space power conversion systems applicable to near-term NASA missions (early 80's) and evaluate the systems for low and high power to permit future planning. This program will include a demonstration of the Brayton power conversion process in the fractional-to-2 kilowatt power level. NASA missions in the early 80's appear to require power levels in the neighborhood of 1 kilowatt. Several of these missions, especially deep space probes, cannot use solar arrays. In addition, certain DOD missions in this time period require compact power systems with long life and in the range of 1 kilowatt power output. To fulfill these needs and especially to provide confidence for mission selection, a proof-of-concept Brayton demonstration system will be designed, built, and run to demonstrate failure-free and unattended operation for a continuous period of at least two years. The 10 kWe engine under endurance testing at LeRC was inspected at 20,000 hours and reassembled for continued endurance testing toward a goal of 50,000 hours.

**W77-70359** **506-23-43**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**NUCLEAR THERMOELECTRIC SYSTEMS TECHNOLOGY FOR SPACE POWER GENERATION**
A. Briglio, Jr. 213-354-6137

Continued exploration of the outer planets will require in many cases the use of improved and advanced isotope power systems. The broad objectives of this RTOP are to perform technology investigations that will: (1) provide a data base to allow NASA to make appropriate selection of the thermoelectric material concept for a given application, (2) enable the establishment of technology readiness dates for thermoelectric materials under development by ERDA, (3) provide long-term power degradation models for future isotope power systems, (4) provide the techniques for integrating isotope power systems with spacecraft, and (5) identify new thermoelectric conversion material which can significantly improve RTG performance. This work will be accomplished by analytical studies and experimental research. Planning and execution of work under this RTOP will be coordinated with ERDA and will be complementary to their programs. The above RTOP objectives are in accord with the NASA PROGRAM and SPECIFIC OBJECTIVES.

**W77-70360** **506-24-11**
National Aeronautics and Space Administration, Washington, D.C.
**PLASMA CORE REACTOR RESEARCH**
K. Thom 202-755-3066
(506-25-31)

The objective is to establish the scientific understanding of gaseous 235 UF6 nuclear reactors and plasma core nuclear reactors for the future development of such energy sources for major advances in space propulsion and in the generation and conversion of nuclear energy in space and on earth. The specific aim is to elaborate the physics of cavity reactors that are fueled

with a gaseous fissioning medium at stationary conditions and under conditions at which the fuel is flowing through the reactor and is confined by a wall jet inflow of buffer gas. In addition, the non-equilibrium distribution of ionized and excited states in the fissioning gas and possibility of non-equilibrium e.m. radiation will be investigated. HQ funded research will be conducted at the Los Alamos Scientific Laboratory (LASL). Gaseous fueled cavity reactor theory and experiments will be utilized to establish the reactor physics of such systems, to prove their safety and control, and to probe their usefulness in respect to the goals. A beryllium moderator-reflector will be employed, in addition to a control system, and a pressure vessel salvaged from the previous NASA Nuclear Rocket Program. LASL will subcontract United Technology Research Center (UTRC) for UF6 handling research and to design and fabricate UF6 canisters and flow systems components for insertion into the reactor cavity. In addition, UTRC will investigate UF6 flow and buffer gas separation systems.

**W77-70361** **506-24-11**
Langley Research Center, Langley Station, Va.
**PLASMA CORE REACTOR RESEARCH**
F. Hohl 804-827-2376
(506-25-31)

The objective is to establish the scientific understanding of 235 UF6 and 235 U plasma-core nuclear reactors and to study their technological usefulness. Emphasis in this basic research is on the physics of fission fragments - gas interactions to understand the mechanisms of nuclear-induced electromagnetic radiation, the transport of this radiation and its conversion to useful forms of energy. In addition, a major effort of research is directed toward fluid mechanical confinement of fissioning gaseous nuclear fuel, materials studies of UF6, uranium vapor handling systems, and argon buffer gas/UF6 separator design and tests. Fluids mechanics, UF6 handling, separator design and testing, and part of the optical radiation research will be conducted under contract under LaRC direction. Other supplementary radiation research is conducted under the LaRC 506-25-31 RTOP. Nuclear reactor experiments will be conducted under a separate NASA Headquarters RTOP.

**W77-70362** **506-24-13**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**NUCLEAR PUMPED LASERS**
G. W. Lewicki 213-354-4530

The primary objective of this work is to develop high pressure lasers where the laser pumping is provided by a pulsed nuclear reactor. A secondary objective is to conduct supporting theoretical and experimental research which will lead to an understanding of the kinetic processes responsible for lasing in high pressure plasmas produced by the products of nuclear reactions.

**W77-70363** **506-24-16**
Lewis Research Center, Cleveland, Ohio.
**BASIC STUDIES IN HEAT TRANSFER AND FLUID MECHANICS**
Lester D. Nichols 216-433-6203

The objective is to provide basic knowledge required to predict and control processes involving hot gases, reacting constituents, coolants, and radiant heat fluxes as they occur in energy-transfer systems. The work involves efforts in the research areas of heat transfer and fluid mechanics. The approach is to study basic behavior and processes applicable to whole classes of energy-transfer systems. Theoretical models of processes are developed and are tested by comparison with experiment. These experiments are generally small scale, and are devised to produce general information needed for predicting performance of full-scale systems.

**W77-70364** **506-24-21**
Lewis Research Center, Cleveland, Ohio
**HIGH-EFFICIENCY THERMIONIC CONVERSION**
James F. Morris 216-433-4000
(506-16-31)

The objective is to acquire the technology required for high-efficiency thermionic conversion of heat from various energy sources for use in a wide range of power-generation applications. The approach is to provide the technology to produce better emitters, collectors, and ion generators through coordinated contract, grant, and in-house theoretic and experimental studies (NASA Thermionic-Energy-Conversion (TEC) Applied-Research-and-Technology (ART) Program). With the resulting reduced electrode work functions and interelectrode losses, more efficient thermionic converters will be demonstrated, which will in turn lead to more effective space power systems.

**W77-70365** **506-24-22**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**LOW-TEMPERATURE THERMIONIC CONVERTERS**
G. W. Lewicki 213-354-4530
(506-24-23)

The overall objective is to improve performance of thermionic converters for space and terrestrial power systems. Quantities being considered for improvements are conversion efficiency, reliability, and ultimate system cost. Immediate objectives are to: (1) increase converter output voltage by reducing arc drops and (2) select electrode materials that can achieve work function less than 1.2 eV which are desirable as collectors in advanced thermionic converters. Use of a hybrid mode has been considered at JPL as an approach for reducing arc drops. A test vehicle having a grooved emitter is being fabricated under a ERDA contract to be tested for demonstrating the reduction of arc drop. In this RTOP the results will be carefully analyzed so that the physics involved in operation can be understood, an optimum geometry can be determined, and an additional experimental converter can be fabricated for further evaluation. Since the emitter will employ two different materials, their compatibility in the converter environment will also be established. The compatibility aspect will also be a key factor in selecting low work function collector materials. The candidate electrodes for low work function collectors include, polycrystalline silicon, Ta, Ta2O5, Nb, and NbO2. These materials will be tested to determine their work functions, effect of contaminants and material integrity especially at elevated temperatures. The hybrid mode converter work will be closely coordinated with Rasor Associated which is conducting plasma physics research, and the electrode work with the LeRC which is doing electrode screening and leading the NASA thermionics device research effort.

**W77-70366** **506-24-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**THERMIONIC SYSTEMS TECHNOLOGY**
G. W. Lewicki 213-354-4530

The long-term objective of this technology effort is to achieve high efficiency nuclear thermionic power subsystem technology readiness for application to space power. The intermediate objective is to establish the feasibility of key technology items, and evaluate the capability for low-cost production of thermionic systems. These objectives are accomplished through system design studies and a well-defined technology effort directed at the component and subsystem levels. Work is to be coordinated with applicable technology efforts from other programs. A typical thermionic power subsystem consists of a heat source, thermionic converters, heat exchanger, heat rejection radiator, pumps, controls, structure, nuclear shielding, power processing, and distribution. The power subsystem is expected to be integrated with electric propulsion in a nuclear electric propulsion (NEP) stage for exploration of the outer planets in the 1990's. Other applications, both for space power and terrestrial power, will be studied as appropriate.

**W77-70367** **506-25-11**
Lewis Research Center, Cleveland, Ohio.
**MHD ENERGY SYSTEMS**
George R. Seikel 216-433-4000
(506-25-11)

The objective is to establish the knowledge required to produce and utilize MHD generators for advanced power and propulsion systems of potential importance to NASA, including both understanding the fundamental physical processes involved and establishing the required enabling technology base for these energy systems. Analytical and experimental studies which include extensive diagnostics will be made. Topics to be investigated

include: MHD generators for both open and closed cycle electric power systems and required superconducting magnet technology. Investigations will include studies to define potential system performance, critical technology needs, system concepts leading to new NASA capabilities and missions, and alternative applications of technology developed.

**W77-70368** **506-25-12**
Lewis Research Center, Cleveland, Ohio.
**HIGH TEMPERATURE PLASMA SYSTEMS**
George R. Seikel 216-433-4000

This RTOP will investigate processes in high-temperature plasmas to obtain the knowledge necessary to produce, confine, and utilize plasmas for advanced power and propulsion systems of potential importance to NASA. Analytical and experimental studies including extensive diagnostic development will be conducted. Related advanced technologies, such as superconducting magnet facilities that are needed to implement these advanced concepts, will be developed.

**W77-70369** **506-25-21**
Lewis Research Center, Cleveland, Ohio.
**MAGNETICS AND CRYOPHYSICS**
Gerald V. Brown 216-433-4000

The objectives are to achieve intense magnetic fields in large volume with minimum mass and power requirement; to conduct research on superconducting materials to improve stability, current density, operating temperature and strength; and to study the low temperature and intense field properties of materials and devices of significance to refrigeration, power and propulsion applications. Basic and applied research in magnetic cooling and solid state physics are included. A new mechanical design and forced convection LNe heat transfer is being applied in a cryogenic magnet to produce a 30 T steady-state magnetic field. (Present record steady field is 22.6 T). High field superconductors (e.g., Nb3Sn) will be produced in a substantially improved composite form to give magnetically stable, high current density magnet windings. University grants will support development of other high field (greater than 200 kG) and high temperature (greater than 20 K) superconductors into usable form. The potential high efficiency of magnetic heat pumps and refrigerators will be evaluated by building and testing devices in the entire range from 4 K to room temperature. A screening program will select and measure properties of candidate magnetic working materials.

**W77-70370** **506-25-22**
Ames Research Center, Moffett Field, Calif.
**CRYOGENIC TECHNOLOGY FOR COOLING DETECTORS BELOW 10 KELVIN**
D. R. Chapman 415-965-5065
(188-78-51; 188-41-55; 188-41-54)

The objective is to provide space compatible technology for photon and wave detectors requiring operating temperatures between 10 and 0.02 Kelvin. Efforts will be directed in three general areas: (1) considerable effort will be continued to maintain cognizance and coordination with all related cryogenic activities within NASA, DoD, NBS, and ERDA to minimize possible duplication of effort, make maximum use of already existing technical talent and knowledge, and identify future NASA technology needs as well as recognize and evaluate possible new applications in this area; (2) development of space compatible cooling techniques and related components for various science detectors and detector packages; and (3) development of methods to protect cold optics from contamination. Both in-house and contractual efforts will be applied as well as subauthorizations to other NASA Centers to make maximum use of technical talent in this discipline.

**W77-70371** **506-25-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SOLITONS IN QUASI-ONE-DIMENSIONAL SYSTEMS**
G. W. Lewicki 213-354-4530
(506-15-28; 505-15-35)

The primary objective of this program is to investigate the possible existence and dynamical properties of solitons in quasi-one-dimensional (1D) systems. The soliton represents a new type of low energy, mobile, charged, elementary excitation and may be schematically visualized as a solitary wave, or pulse, in the electronic charge density which propagates through the lattice. The soliton owes its existence to the presence of strong nonlinear interactions such as those associated with an anharmonic potential. Soliton conduction should be characterized by unusual electrical, magnetic, and optical properties since solitons do not appear to be scattered by impurities or defects as effectively as other charge carriers, e.g., electron. At the present time, practically nothing is known about the soliton contribution to the transport properties. The formidable mathematical complexities associated with the nonlinear processes of soliton conduction are greatly reduced by considering systems of quasi-1D geometry. A theoretical and experimental approach is proposed which is focused on the nonlinear process of soliton conduction in quasi-1D materials such as (TTF)(TCNO). The objective of the program will be to develop a model incorporating soliton charge carriers from the beginning as fundamental constituents. Basic elements of such a soliton conduction model already exist as a result of a previous mathematical investigation of solitons carried out at JPL (RTOP 505-15-35). The theory will be used to predict the electric, thermoelectric, and optical properties. The initial experimental program will involve the measurement of the current voltage (I-V) characteristics as a function of electric field and temperature in (TTF)(TCNO) and its derivatives. Preliminary theoretical studies indicate that the presence of solitons should result in a nonlinear electric field dependence of the dc conductivity, particularly at low fields and low temperatures. If such nonlinear behavior is discovered, information regarding the energy spectrum of solitons will be obtained and subsequently incorporated into the theoretical model.

**W77-70372** **506-25-24**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SUPERCONDUCTING DIGITAL MICROCIRCUITS AND SYSTEMS**
G. W. Lewicki 213-354-4530

Digital microcircuits based on superconducting technology and Josephson-effect devices could provide important advantages compared to other technologies. Improvements of two orders of magnitude in speed, power consumption, and circuit density have been projected on the basis of laboratory tests. Improvements in reliability and radiation immunity are also possible. If these features could be realized in practical systems, they would be of great value both for NASA programs and outside NASA. However, at present there is no systematic program in NASA to evaluate these possibilities. The objective of this program is to determine to what extent the projected features given above can be realized in practical systems and to develop a technology base for subsequent applications of this technology. The total program has an expected duration of 6 years, with funding of $1 million. The technical plan comprises these parts: (1) fabricating and evaluating basic digital logic gates based on the proximity device, a type of Josephson-effect structure which appears to offer the best potential for practical circuits and technology; (2) developing a method of interfacing these gates in order to make more complex circuits; and (3) fabricating and measuring the performance of a prototype data-processing system of medium complexity, based on superconducting devices and technology. Supportive materials work will also be carried out. One of its goals will be to establish an operating temperature for these circuits of 15 K, by adapting existing high-temperature superconducting materials. At the conclusion of the program a technology base will have been established for subsequent applications of superconducting digital systems.

**W77-70373** **506-25-31**
National Aeronautics and Space Administration, Washington, D.C.
**FUNDAMENTAL PHOTONICS**
K. Thom 202-755-3066
(506-24-11)

This effort uses fundamental physics research on e.m. radiation-matter interactions, to explore the principles of the generation, conversion, and utilization of power at energy levels much higher than used in conventional thermodynamic systems,

for greatly improved capabilities in space propulsion and the usage of energy in space and on Earth. Particular emphasis is on means of power generation from fission fragment-gas interactions in form of e.m. radiation in the visible to ultraviolet spectrum, to generate laser power directly in this spectral range, and to investigate basic principles of the direct conversion of laser power into electricity, or mechanical work, without going through phases of thermalization of energy.

**W77-70374** **506-25-31**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**FUNDAMENTAL PHOTONICS**
G. W. Lewicki 213-354-4530
(506-25 31; 506-25-41)

The objective of the laser kinetics task is to conduct the research required to develop various types of high power, efficient, short wavelength lasers. Emphasis is placed on understanding the basic physical phenomena that determine the efficiency, wavelength, size, and power output of laser devices. The basic objective of the electron impact spectroscopy task is to obtain spectroscopic information and cross sections for electron-atom, molecule, ion interactions that are needed in understanding the behavior of various laser and plasma devices, and the thermalization process of high energy electrons. The objectives of the nuclear Zeeman maser and gamma-ray laser task are: to study the feasibility of constructing a nuclear Zeeman maser, to investigate its characteristics as an oscillator and as a low temperature rf amplifier, and also to apply the NMR line narrowing technique to Mossbauer systems which might eventually lead to the gamma-ray laser system. Experimental development of distributed feedback (DFB) will be confined to fiber-geometry laser systems in an attempt to solve certain coupling problems associated with small scale lasers and laser light transmission systems and to investigate possible useful devices. In the physics of molecular interaction program, basic research on the chemical and physical interactions of ions, electrons, metastables, and molecules is conducted, with particular emphasis on processes involving the production of excited states. A related applied research study is underway to develop a new class of charge transfer ion lasers.

**W77-70375** **506-25-31**
Lewis Research Center, Cleveland, Ohio.
**FUNDAMENTAL PHOTONICS**
J. W. Blue 216-433-4000

The objective is to use LeRC cyclotron to excite atoms and nuclei for purposes of creating: (1) excited nuclear states (isomers) which will be studied for their possible application in a gamma ray laser, (2) radiation damage effects in transparent fused silica and beryllium oxide which simulate the damage caused by the radiations of a fusion or fission reactor, (3) radioactivity for use in applications where radioisotopes are used as tracers and identified by the photon emissions, and (4) vacancies in inner atomic shells which emit characteristic X-rays and thereby allow identification as trace elements. The approach is to: (1) study nuclear levels in a material arrangement in which the excited species are in a single crystal whisker form. Such preferential alignment is considered to be necessary for a gamma ray laser, (2) bombard transparent materials with high-energy protons and to simultaneously determine the absorption of a light beam with a wavelength in the range 200-600 nm as function of temperature and dose rate, (3) produce radioisotopes (TI-201, XE-129m, I-123) and then turn them over to a clinician for appropriate studies, and (4) perform analyses for trace elements on air and water environmental samples.

**W77-70376** **506-25-31**
Langley Research Center, Langley Station, Va.
**FUNDAMENTAL PHOTONICS**
Paul F. Holloway 804-827-2893

The fundamental characteristics of a fissioning uranium plasma will be investigated to determine the feasibility of direct conversion of nuclear energy into electromagnetic radiation, laser power or work. The thermodynamic properties of uranium hexafluoride will be investigated, and the interaction of fission fragments with uranium hexafluoride and other gases will be determined. Radiation induced plasmas will be studied to determine possible population inversion, nonequilibrium emission, and ionization and excitation cross sections. A new hypocycloidal plasma focus will be tested with greatly increased plasma confinement time. The increased neutron production expected from this device should improve the production of fissioning uranium plasmas by increasing fission yield. The interaction of intense CO2 laser radiation with the dense plasma focus will be investigated, specifically the efficient conversion of laser radiation to x-rays. Various noble gas lasers (Ar, Xe, etc.) will be investigated to achieve direct nuclear-pumped lasers by volume excitation. A new hypocycloidal plasma focus will be tested for possible use in the production of a fissioning uranium plasma and direct nuclear laser pumping. Research on fission-fragment induced plasmas, on characteristics of the radiation emitted from fissioning plasmas, and on nuclear induced population inversion will be performed under grants to various universities. The Army Fast Pulse Reactor at Aberdeen will be used as the neutron source to perform direct nuclear pumped laser experiments.

**W77-70377** **506-25-32**
Ames Research Center, Moffett Field, Calif.
**QUANTUM ELECTRONICS**
D. R. Chapman 415-965-5065

The objective is to conduct experiments and analysis leading to the development of short wavelength lasers and other sources of coherent radiation suitable for currently foreseen NASA applications such as space power transmission, laser propulsion, remote sensing, and photoenhanced chemistry. Mindful of the constraints of such space application, lasing candidates and converters will be examined which exhibit potential for having short wavelength, high average power, reasonable efficiency, closed cycle operation, scalability, and long-term maintenance-free operation. Selected candidates will be further investigated by comprehensive modeling, using our extensive capabilities in the computation of molecular enenrgy levels, pertinent cross sections, and susceptibilities and kinetic rates of both excitation and de-excitation. Finally, attainment of inversion and harmonic production will be experimentally verified. This will entail the understanding and technological development of efficient, stable, and scalable (non e-beam) means of excitation, especially in supersonic flow.

**W77-70378** **506-25-34**
Ames Research Center, Moffett Field, Calif.
**PHYSICS AND CHEMISTRY OF GASES**
D. R. Chapman 415-965-5065
(506-16-12)

The primary objective is to advance the state-of-the-art of computing wave functions for the ground and excited states of polyatomic molecules and atomic clusters, by exploiting the unique computer power residing at NASA-Ames. The calculated wave functions will be used to compute molecular properties, such as electronic transition moments, dipole moments, bond dissociation energies, potential surfaces and photo dissociation cross sections. A secondary objective is to improve the accuracy of the excited state wave functions for diatomics, and apply these techniques to polyatomic systems. The computer programs developed in this research will be widely applicable and will be capable of producing properties of great utility in the areas of laser development and applications, re-entry physics, stratospheric pollution studies, and materials science.

**W77-70379** **506-25-35**
Ames Research Center, Moffett Field, Calif.
**STRUCTURE AND PROPERTIES OF SURFACE LAYERS**
D. R. Chapman 415-965-5065

The objective is to investigate the detailed structure and physical properties of epitaxially adsorbed layers of metallic and semiconducting materials on well defined single crystal substrates, and to study the change of adsorption properties when co-adsorbing active gases. The particular surface properties to be measured and correlated are crystallography and mode of growth chemical composition (impurities), binding energy, and electronic work function; they will be determined as a function of

coverage or thickness (sub- and multilayer range), substrate structure, thermal treatment, and radiation environment.

**W77-70380** **506-25-41**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**HIGH POWER LASER SYSTEMS**
G. W. Lewicki 213-354-4530

The objective is to develop the necessary technology required to construct various types of high-power, efficient, short-wavelength lasers. Emphasis is placed on the development of scaling laws that govern the efficiency, size, and power output of specific laser devices.

**W77-70381** **506-25-41**
Lewis Research Center, Cleveland, Ohio.
**HIGH-POWER LASER SYSTEMS TECHNOLOGY**
D. J. Connolley 216-433-4000
(506-21-40; 506-17-11; 506-16-21)

The objective of this program is to evaluate by 1980 the potential of high-power lasers for NASA applications. This program will define and investigate high-power laser systems and their potential use. Both space and ground-based systems for potential NASA, commercial, and/or military applications will be included. A broad technology base will provided, as necessary, for realistic appraisal of systems and applications, and for future design, development, and use of such systems. Efforts will concentrate on evaluation and technology investigations of flowing gas laser devices suitable for future high-power laser transmitter systems, efficient power generation systems for such devices, conversion systems for high-power laser energy receivers, optical components unique to large high-power lasers, and on screening and definition of applications. The program approach includes: (a) identification of potential applications and in-depth evaluation of their requirements (a continuing effort); (b) component performance and system studies; (c) experimental investigation of component and subsystem technology within critical areas; (d) design and operation of high-power lasers to assist in the component technology investigation program; (e) design, fabrication and testing of high-power laser transmitter systems for evaluation of system-type problems; and (f) design, fabrication, and operation of systems and experiments applicable to potential applications, including laser propulsion.

**W77-70382** **506-25-41**
Ames Research Center, Moffett Field, Calif.
**LASER ENERGY CONVERSION**
D. R. Chapman 415-965-5065

The objective is to develop methods and devices for conversion of coherent radiant energy to useful work with efficiencies approaching 50 percent or greater, and methods of detection and discrimination of very weak coherent radiation signals. Five basic approaches have been identified and are being investigated: (1) use quantum tunneling at junction diodes to rectify the coherent electromagnetic field radiation directly to electrical output; (2) absorb the radiation in the working fluid of a Carnot cycle heat engine; (3) absorb the radiation in the plasma region of a thermoelectric direct energy conversion device to raise the electron temprature in the plasma and thereby increase its efficiency; (4) use coherent rabiation to photo dissociate water adsorbed on surfaces of catalytic substrates, and then separate the H2 and O2 gases for chemically stored fuel; and (5) absorb the energy in internal degrees of freedom of the working fluid of an engine and extract work isentropically.

**W77-70383** **506-26-10**
Langley Research Center, Langley Station, Va.
**ADVANCED EARTH-ORBITAL TRANSPORTATION AERO-THERMODYNAMICS**
B. Z Henry 804-827-3911
(790-40-07)

The objective of this study is to develop configuration design concepts and the associated aerothermodynamic technology data base which will allow the achievement of space transportation vehicles operational in the 1990's and beyond which offer significant improvement in operational efficiency, economy, and safety. The intent is to study, both analytically and experimentally, configuration concepts utilizing technologies advanced beyond the base being established by the space shuttle. Specific studies will be directed toward solution of the aerothermodynamics problems associated with these concepts in such areas as aerodynamic performance, viscous interaction and real-gas effects, vortex interactions, heat transfer, basic configuration shaping, and optimization. Computational flow field methods will be developed with emphasis on realistic configurations, and techniques for configuration design and analysis will be upgraded as required. Various perfect gas and real gas facilities will be utilized in experimental investigations to provide design data over a broad range of parameters.

**W77-70384** **506-26-11**
Langley Research Center, Langley Station, Va.
**SUPPORTING RESEARCH AND ANALYSIS FOR SHUTTLE AEROTHERMODYNAMICS FLIGHT EXPERIMENTS**
G. D. Walberg 804-827-3031
(506-26-10; 750-75-02)

The planned operational flight frequency of the shuttle, coupled with its large payload carrying capability will provide an unprecedented opportunity for conducting aerothermodynamic research as an adjunct to orbital operations. Prior studies have identified several potentially atractive flight experiments which will utilize the shuttle's normal interaction with its environment during ascent and reentry and/or entry vehicles launched from the shuttle orbiter. The present RTOP continues this work. Its objectives are to establish the research and technology need and justification for selected shuttleborne aerothermodynamic experiments, develop the necessary research & technology data base to support the experiments, and perform the necessary post-flight data analysis and reporting of the experimental results. In FY 1976; attention was concentrated on measuring shuttle leeside temperatures using an IR camera. In the transition period, & FY 1977, this work will be continued and conceptual definition studies will begin on the use of instrumented TPS tiles for local heat transfer studies on the orbiter. The approach to be used involves: (a) review of existing state-of-the-art to identify fruitful flight experiments, (b) studies to insure compatibility of proposed experiments with the shuttle, other payloads, & the mission model, (c) studies to develop advanced instrumentation techniques, (d) analyses & tests required to resolve critical feasibility issues, and (e) analysis and reporting of results.

**W77-70385** **506-26-12**
Ames Research Center, Moffett Field, Calif.
**DEVELOPMENT OF INSTRUMENTATION FOR THE MEASUREMENT OF FLOW-FIELD PARAMETERS**
D. R. Chapman 415-965-5065
(505-06-13; 506-26-22)

Measurements of flow-field parameters and interpretation of these measurements are the keys to the advancement of our understanding of fluid mechanics. Theoretical developments must rely upon experimental verification. Even with the advent of presentday powerful computing techniques, we must have accurate measured data for normalization and base data for idealized cases. As an example, advanced studies of turbulence are severly hampered by the lack of accurate means of measuring local values of fluctuating pressures, temperatures, densities, and velocities, as well as the spatial and temporal variations of these quantities. The work of this RTOP is directed toward the continuing development of adequate experimental instrumentation for fluid mechanical research programs. The approach to be followed will be to adapt new developments in spectroscopy and lasers to flow diagnostics problems rather than simply attempt to improve on presently existing technology. However, in several selected areas, existing technology will be explored with the view of making improvements by devising new fabrication techniques to improve the instrumentation.

**W77-70386** **506-26-20**
Langley Research Center, Langley Station, Va.
**PLANETARY ENTRY AEROTHERMAL R&T**
P. F. Holloway 804-827-3031
(506-26-20)

The objective is to establish the technology base necessary

to assure survival and reliable performance of scientific probes during entry into the atmospheres of Mars, Venus, the outer planets, and certain natural satellites such as Titan. The technology readiness target schedule, which assumes a cutoff in technology development 3 years prior to launch, is late 1977 for Jupiter (Pioneer Jupiter Orbiter/Probe) and late 1978 for Saturn and Uranus. This target schedule is the key to the specific task milestones. The objective will be pursued using analytical and experimental methods and will be conducted primarily in-house with contract support as justified. This work will encompass the following topics: (A) studies to define hypervelocity entry vehicle heating and aerodynamic environments, minimize thermal protection requirements, and optimize probe configuration on the basis of heating, thermal protection, aerodynamic performance, packaging, and science experiment requirements; and (B) advancement of aerothermodynamics technology pertinent to planetary exploration through continued development of computational techniques and utilization of the STAR, upgrading of existing facilities and development of improved experimental techniques and measurement capability, and maximum utilization flight verification data as available (Viking and Pioneer Venus).

**W77-70387** **506-26-21**
Ames Research Center, Moffett Field, Calif.
**GAS DYNAMICS RESEARCH**
D. R. Chapman 415-965-5065

The objective is to advance the analysis of high energy flow processes including precise physical models of thermodynamic and transport properties of matter and rigorous treatments of kinetic rate processes, radiative transfer, and ablation product chemistry. Classical, semiclassical, and quantum theories of gaseous matter are explored to find the most efficient models for large, high-speed computer programs of gasdynamic flows. These models are tested against experiment and then extrapolated to the conditions of interest in the earth's upper atmosphere, in flow about high altitude hypersonic aircraft and space shuttle vehicles, and in the flow about probes in planetary atmospheres. The Monte Carlo method of modeling fluid flow by numerical methods will continue to be developed using large size, high speed, parallel processing computer facilities available at Ames. Rigorous scattering and nonadiabatic collision processes are included in these calculations for the purpose of determining the limits of validity of the Navier-Stokes model of fluid flow with coupled chemical processes, and for determining transport properties of reactive gases more rigorously than with the usual linearized theories. In addition to the above, some studies will be made of the properties of ablation specie gases (such as C2,C3,SiO) that block radiation from reaching the surface of high speed space shuttle and planetary entry vehicles.

**W77-70388** **506-26-22**
Ames Research Center, Moffett Field, Calif.
**COMPUTATIONAL AND EXPERIMENTAL AEROTHERMODYNAMICS**
D. R. Chapman 415-965-5065

The objective is to develop the aerothermodynamic technology required to define the flow field around entry vehicles. Emphasis is on the development of turbulence models from numerical and physical experiments. These models will be used in computer codes that numerically simulate the flow fields. Numerical and analytical studies will be performed to develop new turbulence models appropriate for high-speed flight and incorporate these models in advanced computer codes. Experiments at supersonic and hypersonic speeds specifically designed to verify these turbulence models and computer codes are to be performed. Additional experiments will be performed, as required, to define and solve fluid mechanics problems for particular classes of entry probes such as the effect of moderate to massive ablation rates on transition to turbulent flow on blunt entry probe shapes.

**W77-70389** **506-26-23**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PLANETARY PROBE DESIGN/OUTER PLANETS**
R. R. McDonald 213-354-6186

The Jupiter Orbiter/Probe Mission now planned for 1981 includes an atmospheric probe system to observe conditions beneath the ammonia clouds covering the planet. Before these observations begin, the probe most survive a 48 km/s entry into an 89 + or - 11% hydrogen atmosphere. During this high speed entry, the shock-heated hydrogen gas radiates very strongly to the carbon heat-shield surrounding the probe, subliming the material and eroding the surface through spalation. Over one-quarter of the probe mass may be lost by evaporation and erosion during this ablation process. The annular arc accelerator shock tube is the only existing facility having the capability to study the radiative characteristics of the probe shock layer gases at the temperatures and pressures existing during Jovian entry. During shock tube tests at speeds to 50 km/s, radiation from the hydrogen/helium gases is observed by radiometers monitoring various spectral bands. The observed radiative intensities are compared to those calculated by the radiative flux codes, thus resulting in improved means of estimating radiative flux to atmospheric entry probes. The uncertainties in the ultraviolet spectra of hydrogen/helium gases will be reduced to less than + or - 25% by the end of FY-TR/77. Our work with total radiation from carbon/hydrogen gases should be well enough along by the end of FY-TR/77 so that the uncertainties in radiative flux will be reduced to + or - 30% at Jovian atmospheric entry conditions.

**W77-70390** **506-26-24**
Ames Research Center, Moffett Field, Calif.
**PLANETARY PROBE AEROTHERMODYNAMIC TECHNOLOGY**
D. R. Chapman 415-965-5065
(506-16-41; 506-26-21)

This effort is directed at providing the aerothermodynamic technology base specified by the Planetary Probe Design Specific Objective of the Entry Technology Program. In that regard, the effort directed at understanding the behavior of outer planet atmospheric gases and atmosphere entry probes is divided into five integrated tasks: (1) radiative gasdynamics, (2) boundary layer and base flow, (3) systemically coupled performance analysis, (4) entry flight mechanics, and (5) facilities development. This work will be applicable to the entry technology requirements associated with entry into all the giant outer planets. The coupled nature of outer planet probe aerothermodynamics requires a highly integrated computational and experimental program. The theoretical and experimental efforts in the area of shock-layer radiation must be coupled with similar efforts in ablation product radiation and absorption. These efforts in turn must be coupled with research associated with boundary layer flow which is highly blown by ablation products. In addition, the flight mechanics of the probe, both static and dynamic, are significantly affected by the ablation mass loss and shape change. Experimental free-flight research is required to provide the required coupling between the vehicle mass and the imposed ablation. Finally, all these theoretical efforts and experimental validations must be systematically coupled computationally to provide the required aerothermodynamic input to outer planet probe development.

**W77-70391** **506-26-30**
Langley Research Center, Langley Station, Va.
**SPACE SHUTTLE DEVELOPMENT SUPPORT**
P. F. Holloway 804-827-3911

This RTOP focuses Langley's expertise in configuration aerothermodynamics and operational flight mechanics on those concerns having greatest impact on successful development of the shuttle. The RTOP supports the Shuttle Program by (1) providing time in Langley ground-based facilities for direct OSF/contractor-requested support, (2) continuing independent in-house shuttle technology and development studies, (3) responding to specifically requested task-study areas from the Program Office at JSC, and (4) maintaining a strong basic aerothermodynamic supporting technology program. In addition, Langley will perform independent evaluations and assessments of the configurations and operational modes and requirements as necessary. This RTOP's program is coordinated with other NASA centers and the Phase C/D contractor through appropriate Office Engineering Coordinates Panels at JSC.

**W77-70392** **506-26-31**
Ames Research Center, Moffett Field, Calif.
**SPACE SHUTTLE: CONFIGURATIONS AND AEROTHERMODYNAMICS**
D. R. Chapman 415-965-5065

The objective is to evaluate the aerodynamic performance, stability and control and heating, of the space shuttle orbiter and launch configuration and ferry configuration to pinpoint and find the solution to aerothermodynamic problems of these vehicles in support of shuttle vehicle development by JSC and its contractors. Models resulting from contractor and in-house studies will be tested in subsonic, transonic, supersonic, and hypersonic facilities of the Ames Research Center. The wind-tunnel data will be used by NASA and shuttle contractors to evaluate the space shuttle and ferry configurations characteristics. Numerical methods and computer programs will be developed for calculating the three-dimensional chemical-nonequilibrium inviscid and viscous real gas windward flow around space shuttle orbiter configurations at angle of attack. Codes will be written for parallel and serial computers, and parametric studies of shuttle entry flow fields will be performed on advanced computers. Sufficient experimental data will be obtained to verify the correctness of the computer codes.

## Space System Studies

**W77-70393** **790-40-12**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**FUTURE DEEP SPACE MISSION CONCEPT-SOLAR SAILING**
R. V. Powell 213-354-6586

The objectives are (1) to analyze potential missions for solar sailing exploitation, to examine the requirements and potential return, (2) to develop mission and system approaches for solar sailing missions in the solar system, (3) to develop a conceptual design for a solar sailing spacecraft, and (4) to identify technology requirements in order to implement solar sailing missions. The approach is to bring together a small interdisciplinary team of workers in the disciplines of mission analysis, structures, materials, attitude control, and system design, and to conduct a study meeting the objectives above. This team will analyze various missions as candidates for solar sailing applications and identify the key technology requirements and possible configurations for a solar sailing vehicle.

**W77-70394** **790-40-12**
Lewis Research Center, Cleveland, Ohio.
**ADVANCED HIGH PRESSURE ENGINE STUDIES**
John W. Gregory 216-433-4000
(506-21-11)

NASA is currently conducting studies of advanced vehicle concepts for the 1990's and beyond time period to provide direction for technology advancements to best meet future national needs and agency goals. Such advanced vehicles include improved Space Shuttle concepts, single-stage-to-orbit (SSTO) shuttle vehicles, low cost heavy lift launch vehicles (HLLV), orbit transfer vehicles (OVT), and lunar transport vehicles. Such vehicles utilize high pressure rocket engine systems and may employ mixed-mode propulsion wherein high bulk density propellants are burned at take-off or during the early portion of flight (mode 1) and low bulk density, higher performance propellants (LOX-LH2) are burned later in the flight (mode 2). A number of different rocket engine configurations may be employed including conventional bell nozzle engines, aerospike, or linear engines. Both high pressure LOX/hydrocarbon engines and dual fuel engines are applicable. During FY 75 and FY 76 work was focused on studies of high pressure bell nozzle engines for mode 1 and mode 2 operation, that employed oxygen or hydrogen cooling, and linear/aerospike rocket concepts using split combustors. In FY 77 effort will be devoted to further evaluation of various other dual fuel and tri-propellant engine concepts over a range of thrust levels suitable for the various vehicle applications and for hydrocarbon fuels such as methane, RP-1, and RJ-5.

**W77-70395** **790-40-14**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**FUTURE DEEP SPACE MISSION CONCEPTS - SAMPLE RETURN TECHNOLOGY DEVELOPMENT**
R. V. Powell 213-354-6586

The objective of this study is to understand and determine when, in our exploration of the solar system, analysis of planetologic samples is best done remotely and when it is best done by return to Earth laboratory. 'Best' in this statement implies most cost-effective in terms of obtaining the requisite data lowest possible cost. To meet this objective we must study (1) sample return technology requirements--this is the FY 76 work and it will be concluded in the transition period, (2) develop a new mission concept--the hybrid mode wherein the sample return concept is integrated with the in-situ mode, i.e., the sample is returned to an instrumented orbiting laboratory, (3) analyze the orbiting laboratory technology requirements, and (4) assess the place of sample return vis-a-vis remote analysis in our planetary exploration program.

**W77-70396** **790-40-22**
Marshall Space Flight Center, Huntsville, Ala.
**PAYLOAD SOFTWARE TECHNOLOGY REQUIREMENTS**
B. C. Hodges 205-872-0134

The objectives of this RTOP are to: (1) estimate the complexity and magnitude of software for future NASA payloads; (2) identify software limitations to desired payload performance and areas of software application with a large impact on program or user cost and/or flexibility; (3) survey and assess the current state-of-art in software technology and determine its applicability to future software; (4) identify opportunities for the advancement of software technology that offer substantial payload benefits; and (5) define programmatic requirements for the advancement of software technology beneficial to payloads. The study approach is structured to capitalize on the experience and data developed in three years of SPDA studies of STS payloads, and takes full advantage of available payload software studies. Future payload software requirements will be identified, defined, and then reviewed with appropriate NASA payload working groups. The software development load will be estimated in terms of number and size of application programs. Extraordinary processing requirements will be identified and evaluated for applicability to software technology advancement. Software cost reduction alternatives will be identified and correlated with the payload software requirements. The current state-of-art in software technology will be assessed and applicability to payloads evaluated. Software advanced technology opportunities will be identified and defined and their programmatic requirements established to allow timely NASA decisions and implementation.

**W77-70397** **790-40-32**
Langley Research Center, Langley Station, Va.
**ADVANCED MISSION CONCEPTS - EARTH ORBITAL TRANSPORTATION SYSTEM TECHNOLOGY REQUIREMENTS**
P. F. Holloway 804-827-3911
(506-26-10)

The objective of this study is to identify the technology required for the design and operation of advanced Earth-orbital vehicle systems for application in the post-shuttle time frame. The intent is to analyze potentially attractive concepts which build upon the technology base developed for the Space Shuttle Program utilizing projected advances in such areas as materials, structural design, and propulsion systems. Definition of approaches to advanced system design and a detailed examination of the relative impact of assumptions as to achievable levels of various technologies offers a suitable means of identifying those technologies which are crucial as well as those most cost effective; this identification will be a primary output of the effort. An inherent characteristic of any such advanced system is that it offers clear and significant cost/capability advantages relative to current systems. Programs to provide solution to key technology issues will be designed based on the results of these studies. The activity will be pursued through a series of contractual system studies, technology planning methodology development studies, and selected in-house analyses as required.

**W77-70398** **790-40-45**
Ames Research Center, Moffett Field, Calif.
**SYSTEMS ANALYSIS OF POST LANDSAT-D/SEOS SYSTEM**
D. R. Chapman 415-965-5065
(683-76-37)

The objective of this RTOP is to capitalize on existing and on-going study results to derive desirable technical characterisitics and research and technology requirements of post LANDSAT D/SEOS Earth observations systems from their functional and user requirements, and to study the sensitivity of the technology implications to the user and functional requirements postulated. The approach is to expand the studies of Earth observation satellite options into the post LANDSAT-D/SEOS timeframe and explore the cost-effectiveness of varying these options as to: sensor complements; data product packages; coverage frequencies; orbit; spatial, spectral, and temporal resolution; user acceptance; etc. The optimal technical characteristics of post LANDSAT D/SEOS systems will be studied as a guide to the research and technology developments necessary to achieve an operational system in the future. The continuing RTOP will emphasize the roles of aircraft, DCP and RPV, and will strengthen the tradeoffs identified and begun in the initiating RTOP of FY 76.

## Space Systems Technology Programs

**W77-70399** **520-71-01**
Langley Research Center, Langley Station, Va.
**SOLID STATE DATA RECORDER**
J. E. Stitt 804-928-3745
(506-18-21)

The overall objective of this project is to provide, by CY 1978, a 10 to the 8th power bit solid state data storage system suitable for replacing tape recorders in many aerospace vehicle applications. In addition to the basic tape recorder operations, the solid state data recorder is to provide a flexible operational command structure for advanced aerospace data systems. Specific intermediate objectives are: design a 10 to the 8th power bit data recorder using bubble technology; develop and demonstrate a basic recorder in a breadboard configuration; develop and fabricate a prototype 10 to the 8th power bit recorder. A two-phase developmental contract is being used to provide the data storage system. This contract is being supplemented by in-house analytical studies and laboratory investigations in critical areas of the recorder magnetic and electronic systems. These studies will be directed towards providing improved operational characteristics, longer useful life, and reduced costs.

**W77-70400** **524-71-01**
Langley Research Center, Langley Station, Va.
**CASTS - COMPOSITES FOR ADVANCED SPACE TRANSPORTATION SYSTEMS**
E. E. Mathauser 804-827-2036
(505-01-34; 505-02-41; 743-01-22)

The broad objective is to increase the maximum operating temperature of resin matrix composite materials for structural applications to 600 F to meet requirements for advanced space transportation systems and payloads. This objective will be achieved through a joint in-house and aerospace industry contract effort which will include, development and characterization of currently available polyimide resins and adhesives and new resin systems. Development of manufacturing and quality control procedures. Development of thermal structural design methods. Design, fabrication and ground tests of small-scale components and full-scale space structure demonstration components.

**W77-70401** **525-71-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**LONG LIFE SPACE STORABLE PROPULSION SYSTEMS TECHNOLOGY**
P. J. Meeks 213-354-2546
(506-21-21; 506-21-51)

The overall objective of this effort is to demonstrate technology readiness of a complete spacecraft-sized, flight-weight fluorine/hydrazine $F_2/N_2H_4$ propulsion subsystem by the end of FY'80, using both past and on-going individual component and system-related developments. The demonstration will consist of a hot-fire test of the complete subsystem to a preselected duty cycle that will simulate a typical application. During FY'77 this system level effort will be initiated. Detailed planning will be completed and an implementation plan will be published. Future missions' propulsion requirements will be examined, and subsystem performance, interface, and overall test requirements established. Flow testing of components to system requirements will be initiated, as will firing tests of pre-prototype injectors and rocket engines. Proposed thermal control and structural techniques will be tested. Preliminary subsystem test planning will be completed. The feed assembly components and rocket engines to be used in this demonstration subsystem will complete advanced development under 506-21-21.

## Space Experimental Programs

**W77-70402** **750-01-11**
Langley Research Center, Langley Station, Va.
**ATL/SPACELAB MISSION MANAGEMENT, DESIGN AND SUPPORT**
P. F. Holloway 804-827-2893
(750-01-11)

Previous Langley Research Center in-house and contractor-supported studies have established the feasibility and practicability of a Spacelab compatible Advanced Technology Laboratory (ATL) concept to conduct advanced research in space. These studies have identified and investigated candidate experiments which will support both the multidisciplinary technologies within OAST and the 'Outlook for Space' themes considered by the NASA. The current study has conducted preliminary assessments of the OAST summer workshop results which designated more than 100 candidate experiments for ATL missions. These experiments are currently being systematically evaluated by OAST to determine relative priorities. The objective of the effort described in this RTOP is to provide to OAST ATL/Spacelab mission management, design and support of technology missions. The approach for conducting this effort will focus on the following four tasks: Task 1, OAST Accommodations Requirements for STS Missions; Task 2, ATL-1/Spacelab-4 Mission Management; Task 3, ATL Integration and Operation Definition; and Task 4, Payload Integration Support for Spacelab Missions Other than ATL. Initial phases (FY-77) of Tasks 1, 2, and 4 will be conducted in-house, whereas, Task 3 will be a contracted effort that will conclude with the selection of the first ATL payload.

**W77-70403** **750-01-13**
Langley Research Center, Langley Station, Va.
**SHUTTLE TECHNOLOGY PAYLOAD PROGRAM SUPPORT**
P. F. Holloway 804-827-2893

The objective of this RTOP is to provide technical analysis and support for the coordination and management of OAST's Shuttle Technology Payload Program including support for the solicitation of experiments to match flight opportunities. Candidate OAST experiment/payload efforts will be evaluated relative to NASA and OAST goals, objectives, and the needs of the OAST technical divisions to provide input recommendations as to OAST's support, appropriate flight schedules, and the scope and justification of the OAST Shuttle Technology Payload Program. Announcement of Opportunities (AO) will be prepared and issued for soliciting and selecting experiments for appropriate flight opportunities; and subsequent analyses, evaluations, and recommendations will be provided.

**W77-70404** **750-01-20**
Ames Research Center, Moffett Field, Calif.
**DEFINITION OF SPACE FLIGHT TECHNOLOGY EXPERIMENTS**
D. R. Chapman 415-965-5065

Ames tasks in support of the definition of Space Shuttle

experiments are as follows: (Task 01-Advanced Technology Radiometer/Column Density Monitor (ATR/CDM) payload Definition) The AIR/CDM objectives are to develop and demonstrate a new approach to on-orbit contamination measurements, and to test and demonstrate advanced IR detectors and cryogenics technology. (Task 05-Shuttle Windward Heating Measurements by IR Imagery) The objectives of the Shuttle Windward Heating Measurements are to evaluate the aerodynamic heating to the windward and side surfaces of the Orbiter. (Task 07-Shuttle Flow-Field Diagnostics) The objectives of the Shuttle Flow-Field Flight Diagnostics are to determine in flight the state of the gas environment both on the Orbiter surface and throughout the boundary and shock layers to verify computer predicted flow fields. T43 forms delineating each of these tasks and associated resources requirements are attached.

**W77-70405** **750-01-20**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**DEFINITION OF SPACE FLIGHT TECHNOLOGY EXPERIMENTS**
Paul J. Meeks 213-354-2546
(506-21-51; 750-01-02; 750-03-01; 506-16-34; 910-08-04; 506-19-14)

Three separate tasks are contained within this RTOP with objectives generally as follows: (1) Propulsion contamination effects module, which includes the planning of exhaust plume backflow experiments using instrumentation such as cryogenic quartz crystal microbalances, mass spectrometers, and Faraday cups, to measure the backflow (flow with a turning angle greater than 90 deg.) and charged particle distribution from chemical and electric rocket thrusters in an experiment package deployed from the Shuttle Orbiter Bay. (2) Superfluid helium technology for space applications, which involves defining a comprehensive plan to provide sufficient scientific and technological understanding of the physical, thermal, and dynamic properties of superfluid helium at zero-g to allow its successful use as a cryogen for experiments to be conducted on the space shuttle. (3) Modular instrument pointing technology laboratory (MIPTL), in which the objective is to define a laboratory facility to be carried on the shuttle for testing in situ a variety of experiments associated with instrument pointing technology at a relatively low cost. The facility would consist of accommodations and support systems for the mount, stabilization subsystems, and associated controls and displays.

**W77-70406** **750-01-20**
Lewis Research Center, Cleveland, Ohio.
**DEFINITION OF SPACE FLIGHT TECHNOLOGY EXPERIMENTS**
Donald A. Petrash 216-433-4000

The objective is to provide for the conceptual design of selected space flight technology experiments employing the Space Shuttle. Definition studies will be performed on selected space flight technology experiments to identify and delineate the technical and programmatic requirements necessary to extend these technologies into space. All proposed experiments are based on R&T efforts currently being emphasized at this Center. All definition studies are scheduled for completion within Fiscal Year 1978.

**W77-70407** **750-01-20**
Langley Research Center, Langley Station, Va.
**DEFINITION OF SHUTTLE FLIGHT EXPERIMENTS**
W. E. Sivertson 804-827-3666

The objectives are to identify and prepare proposals for new experiment definition efforts, and to define technical and programmatic requirements for those flight experiments which complement OAST-sponsored space research and technology efforts. Experiment definition efforts for promising space flight technology experiments will be carried out by a combination of contracted studies, grants and in-house studies. Contractual efforts will be aimed at experiment definition, preliminary design, analysis, and preliminary costs and schedules estimates. In-house studies will involve limited computer analysis and laboratory investigation of sensors, components, and breadboard hardware. Promising proposals resulting from these efforts will be selected for flight developments.

**W77-70408** **750-01-20**
Marshall Space Flight Center, Huntsville, Ala.
**DEFINITION OF SPACE FLIGHT TECHNOLOGY EXPERIMENTS**
L. S. Yarbrough 205-872-1023

This RTOP defines multi-disciplinary technology experiments to demonstrate the readiness of these disciplines to support various on-going and planned missions which require or exploit the use of the Shuttle transportation system. The approach is to extend the results of the OAST Summer Workshop by means of definition studies for the following specific flight experiments: (1) End-to-End Integrated Data System, (2) Space Teleoperator Experiment Vehicle, (3) Large Lightweight Solar Array, (4) Aeromaneuvering Orbit-to-Orbit Stage Model Demonstration, (5) Large, Erectable and Repositionable Space Structure with Tethering, (6) Passive Propellant Acquisition System, and (7) Thermal Control System Heat Pipe Module.

**W77-70409** **750-01-51**
Langley Research Center, Langley Station, Va.
**DEFINITION OF PHYSICS AND CHEMISTRY EXPERIMENTS IN SPACE**
P. F. Holloway 804-827-2893

This RTOP is composed of two aspects of the total PACE program: (1) management of the PACE Working Group and (2) definition of Molecular Beam Lab (MBL) experiments. (1) PACE develops uniform procedures for the phased development of basic and applied in-space science experiments, fosters both new general areas for experiments, and definition of specific experiments, and it recommends mature in-space experiments for flight status. These specific, mature experiments are used to justify flight facilities. (2) Definition of MBL experiments requires sufficient delineation of the facility to identify the potential capabilities of this unique instrument and also detailed definition of specific scientific experiments which can be performed in MBL. To achieve these objectives, theoretical studies to define instrumentation characteristics such as beam energy distribution and definition studies of specific experiments are performed.

**W77-70410** **750-01-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**DEFINITION OF PHYSICS AND CHEMISTRY EXPERIMENTS IN SPACE**
G. W. Lewicki 213-354-4530
(750-03-01)

The objective of this effort is to develop a strong Physics and Chemistry in Space Program by generating a broad range of experiments of high scientific value and proven feasibility. Studies by outside scientists will be sponsored to generate and define experiment concepts, and then to determine the feasibility of the experiments selected for further development. Ultimately the experiments will be performed using experiment flight modules in which an entire class of related experiments can be carried out. Potential modules of JPL interest are a superfluid physics experiment module, and a relativity and gravitation experiment module. JPL scientists are continuing a feasibility study for superfluid experiments to study the generation and destruction of quantized superfluid helium vortices, and to study the dynamics of a free superfluid helium drop. In addition, a preliminary study will be undertaken of an experiment to determine the behavior of quantum capillary wave on a thick superfluid helium film. An out-of-house preliminary study will be initiated on the superfluid behavior of 4He/3He emulsions. Past studies have included experiments in: drop dynamics, fluid dynamics, combustion, relativity, wall-less chemistry, and quantum fluids.

**W77-70411** **750-01-51**
Marshall Space Flight Center, Huntsville, Ala.
**DEFINITION OF PHYSICS AND CHEMISTRY EXPERIMENTS IN SPACE**
W. C. Cliff 205-872-0875

The objective of this RTOP is the conduct of scientific and feasibility studies of candidate experiments, in the area of the

physics and chemistry of fluids (single and multiphase), which require and utilize the unique zero or low gravity environment of earth orbit. The candidate experiments (tasks listed below) are motivated by the need to resolve fundamental scientific problems and issues which are of significant importance in the areas of pure and applied physics and which relate to national needs. Individual objectives are: (1) the development of a model and theory for the kinetics of the scavenging of aerosols by walls, (2) the development of a model and theory for the effects of gravity on two phase flow phenomena. The approach for this effort will be to develop theories and experiments for a zero-gravity environment which will address the scientific issues posed in the objective. Specifically, the development of theory and experiment will (1) separate gravitational scavenging of particles from wall scavenging, (2) separate the gravitational slippage from the fluid acceleration slippage (relative motion) in two phase flows. To accomplish these objectives, the following tasks will be performed: (Task-01) zero-gravity Aerosol Behavior, and (Task-02) zero-gravity Two Phase Turbulence.

**W77-70412** **750-01-53**
Lewis Research Center, Cleveland, Ohio.
**DEFINITION OF FLUID PHYSICS AND COMBUSTION SPACELAB EXPERIMENTS**
D. A. Petrash 216-433-4000

The general objectives of the program conducted under this RTOP are to provide specific proposals for experiments to be conducted in the Spacelab of the Shuttle. Analytical as well as experimental programs conducted on the ground and in the LeRC Drop Tower facilities will provide the information from which these proposals will be drawn. During fiscal year 1974, overview studies on fluid physics and combustion were conducted by scientific experts in the private domain in order to identify areas in which worthy Spacelab experiments could be conducted. The studies to be carried out and the principal investigators involved will primarily be determined by the recommendations of these overviews. Although the majority of the research will be conducted by non-NASA personnel, in-house work is also being carried out.

**W77-70413** **750-02-01**
Langley Research Center, Langley Station, Va.
**LONG DURATION EXPOSURE FACILITY PROJECT**
H. T. Wright 804-827-3265

The broad LDEF Project ojbectives are the following: to develop LDEF, a simple, low-costs, free-flying facility for performing long duration technology and other experiments in the space environment using the STS, to develop a first set of experiments for the facility and, by the performance of these experiments, obtain valuable technological data and demonstrate the unique shuttle/LDEF capabilities and features, and to broaden the STS user community by providing a simple low cost approach to integrate and operate a large number of OAST and other unmanned long duration experiments via the STS. The LDEF is a reusable, unmanned, low-cost, free-flying structure on which many different experiments can be mounted. The facility will be delivered to Earth orbit by the shuttle. After an extended period in orbit, the facility will be retrieved on a subsequent shuttle flight and returned to Earth for experiment analysis. Many of the experiments being considered for the LDEF are completely passive with the active data measurements being made in the laboratory after the experiments are returned.

**W77-70414** **750-03-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**DEVELOPMENT OF A SHUTTLE FLIGHT EXPERIMENT: DROP DYNAMICS MODULE**
G. W. Lewicki 213-354-4530

The principal objective of this RTOP is to design, fabricate, and test an acoustic positioning and manipulation module for Spacelab and to utilize it to perform an initial set of experiments as part of the NASA Physics and Chemistry in Space Program on an early Shuttle/Spacelab flight. The module is scheduled to be ready for the ESA-NASA joint Spacelab mission, and will be available for Spacelab flights thereafter. This acoustic positioning and manipulation module will allow us to utilize the unique zero-G environment provided by a Shuttle/Spacelab flight to perform drop dynamics experiments that are impossible to perform in a gravitational field. Examples are: (1) study experimentally the problems first proposed by Newton, and never satisfactorily studied, of equilibrium figures and the bifurcation processes of a rotating spheroid, and (2) understand the fission and fusion processes in drops that are also applicable to meteorology and nuclear physics. The scope of this work is threefold: first, to determine the maximum capability of this facility within the constraints of money and schedule, through consultation with the scientific community and investigators. Second, to fabricate a flight unit, and third, to perform an initial set of experiments (Drop Dynamics), as part of the NASA Physics and Chemistry in Space Program. The scientific community will be invited to participate in experiments informally through international symposia and colloquia. Some scientists will participate with JPL as science associates and consultants. Others will presumably submit experiments in response to NASA AFO's.

**W77-70415** **750-03-02**
Marshall Space Flight Center, Huntsville, Ala.
**DEVELOPMENT OF AN INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM)**
R. J. Naumann 205-872-0940
(910-13-00)

The broad objectives for the STS Induced Environment Contamination Monitor are to conduct an indepth survey of the potential contamination of experiments from the induced environment in and around the STS on the early orbital flight tests (OFT) of the Orbiter, LDEF, and Spacelab during all mission phases in order to: (a) verify the specified requirements in Volume X of JSC 0770, (b) provide diagnostic data to identify any sources that contribute to out-of-specification conditions so that corrective action may be taken, (c) measure the contamination effects from delivery, deployment, retrieval, and landing a free-flying payload, and (d) perform routine monitoring to detect any anomalous operating conditions such as leaks in the hydraulic, coolant, or fuel system; sloughing off particulates from TPS, insulation, or experiments; outgassing from new components or various experiments, etc. Basic instrumentation concepts have been established and bread-board instruments are being procured for evaluation. A Proposal Stage Program Plan for an FY77 New Start has been approved, and the IECM Project Plan is presently being developed for FY77.

**W77-70416** **750-04-03**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**AERODYNAMIC PARAMETER IDENTIFICATION INSTRUMENTATION PACKAGE (OEX NO. A-9)**
Richard E. Day 805-984-8226

The objectives are to provide data accuracy for extraction of aerodynamic derivatives and to provide quality data for other orbiter experiments, comparison between flight and ground facility tests, and aid in the design of future vehicles and improvement of Orbiter performance. The Autonomous Data Package has been designed, constructed, calibrated and partially tested. Package number one was shipped to JSC on August 2, 1976 for additional testing. JSC will deliver the package to RI on September 1, 1976 for installation on Orbiter 101.

# OFFICE OF APPLICATIONS

## Earth and Ocean Physics

**W77-70417** **161-01-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**EARTH DYNAMICS STUDY AND SUPPORT**
A. W. Newberry 213-354-7240
(161-03-14; 369-02-08; 681-01-03)

The objective of the work proposed here is to carry out a set of activities leading to a long range Earth Dynamics Program Plan. JPL proposes to bring about an update and extension of prior programmatic thinking in this area by performing studies and analyses bearing on major programmatic thrusts such as:

support for all phases of the validation team planning and the Earth Dynamics Program Planning Activity as directed by the Special Programs Office, OA, developing a plan for utilization of UTI/Polar motion and radio source position measurements from the DSN platform parameter program by other governmental agencies, developing a mathematical model of the elastic mantle, liquid core, and solid inner core which include those physical phenomena which can measurably affect mantle motion, using Utl/polar motion data (VLBI, LASER) to evaluate and upgrade the model as well as the model to suggest data gathering strategies, and analyzing space and time crustal deformations of selected areas of geophysical interest to define the data base necessary to separate out the various causative factors.

**W77-70418** **161-01-06**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**EARTH DYNAMICS CONFERENCE: UPDATE OF 1969 WILLIAMSTOWN CONFERENCE**
A. W. Newberry 213-354-7240

A one week conference will be held in the spring of 1977 to review progress made in earth dynamics since the 1969 Williamstown Conference. The report of the 1977 conference and its recommendations will be used in conjunction with NASA Headquarters to update the Earth Dynamics Applications Program Plan.

**W77-70419** **161-02-01**
Goddard Space Flight Center, Greenbelt, Md.
**EARTH DYNAMICS**
David E. Smith 301-982-4555
(369-02-01; 161-07-02; 161-03-03)

This study proposes to develop maximum data analysis techniques for the determination of plate motion and polar motion by devising: (1) models of the motions of the earth's major tectonic plates, of the earth's rotation, and of seismically active regions; (2) techniques for the precise measurement of these motions, and for the interpretation of the measurements and models; and (3) improved laser ranging systems for the measurement of geodynamic parameters. Mathematical relationships between plate motion, crustal deformation and seismicity will be developed as part of a global tectonic model encompassing subduction zones, ridges and faults. New techniques for the determination of earth rotation will be developed and new analysis procedures employed in the spectral analysis of the earth's rotation. Mathematical techniques for the construction of earth models will be investigated and applied to a simplified model of a seismic region. New advanced receiver and timing technology will be developed and tested, and advanced signal processing and analysis developed to exploit the millimeter resolution capability of a new receiver system.

**W77-70420** **161-02-04**
Ames Research Center, Moffett Field, Calif.
**SOLID EARTH DYNAMICS/EARTHQUAKE PREDICTION/ MAGNETIC FIELD DETERMINATION**
D. R. Chapman 415-965-5065

The objective is to develop and validate new methods for predicting probable time, location and intensity of earthquakes using NASA-developed vector magnetic sensor technology. Approach: The U. S. Geological Survey and NASA-ARC are jointly conducting a series of field experiments designed to observe weak stress-induced magnetic signals associated with the San Andreas Fault. The U. S. Geological Survey provides seismological and other geophysical direction, and support of field operations, and is responsible for data interpretation. NASA-ARC is coordinating and directing the joint project, contributing newly developed magnetic sensors and technology, providing magnetic standards facilities, furnishing data reduction services, and operating and maintaining limited networks of the NASA-furnished magnetic sensors during the course of the experiments. The California Division of Mines will also participate in experiment planning, data interpretation, and data use. As data becomes available, the National Science Foundation will be invited to participate in the development of theoretical models of the piezomagnetic behavior of faults.

**W77-70421** **161-03-01**
Wallops Station, Wallops Island, Va.
**SEA STATE, WINDS, AND SURFACE MEASUREMENT TECHNIQUE DEVELOPMENT**
N. E. Huang 804-824-3411
(161-03-04; 161-07-02)

Experiments to determine synoptic sea state and surface wind conditions from microwave radar systems are the primary focus of this study. Emphasis is placed equally on a practical evaluation of techniques and on a detailed understanding of air-sea interactions and wave dynamics, so that an accurate, predictive sea state model can be made. The objectives are to make necessary improvements in techniques and in models of varied sea state and wind field conditions for immediate as well as long term applications. Approach: Theoretical analysis, system development efforts, laboratory and field experimentation, reduction of field data, and model derivations will all be used to accomplish the overall plan objectives. Models will be evaluated and possibly modified through the use of data obtained from laboratory and field experiments using buoys, the Chesapeake Tower and various flight tests. In the field experiments, the GEOS-3 altimeter data will be emphasized to develop significant wave height model, but active as well as passive microwave systems and laser profilometers will also be used. The laser system being the most precise instrument at this time, will be used to provide calibration and reference for the other systems. Ground truth activity will be an integrated part of this study to provide data to aid in establishing quantitative relationships between parameters measured and the true phenomena.

**W77-70422** **161-03-02**
Goddard Space Flight Center, Greenbelt, Md.
**MODELS OF THE AIR-SEA INTERFACE**
J. L. Mueller 301-982-2895
(176-30-41)

The objective of this RTOP is to develop the ability to apply satellite data to the study of ocean circulation and wave dynamics. Immediate emphasis is to prepare models, algorithms and data-handling software for interpreting SEASAT-A and NIMBUS-G data in this context. Development will continue on numerical ocean dynamics models which, when operated diagnostically with inputs of satellite-derived sea surface boundary conditions and in situ data, may be used to infer subsurface oceanographic parameters. Research will be renewed to develop and test models relating temperature and color contrasts associated with ocean fronts and coastal current eddies to the dynamics of those phenomena. Theoretical modeling, aircraft field measurements and data analysis will explore and demonstrate the capability of a short pulse (real aperture) radar to measure ocean wave structure and surface wind speed. In FY 77 we expect to report significant results from: (1) computational trails of finite element ocean circulation models, (2) numerical experiments with one-dimensional air-sea interaction and ocean mixed layer models, (3) testing of a sea ice dynamics model with Nimbus ESMR data, and (4) comparison of short pulse radar data of ocean waves with wave observations supplied by cooperating (non-NASA) participants in the 1975 JONSWAP experiment and summer 1976 CV-990 experiments.

**W77-70423** **161-03-03**
Goddard Space Flight Center, Greenbelt, Md.
**OCEAN DYNAMICS TOPOGRAPHY AND GEOID**
W. D. Kahn 301-982-4554

The objective is to develop theories of and models for the ocean geoid, effects of ocean loading on coastal regions, detailed regional geoids, and general representations of the ocean topography based on both satellite and surface data. Direct measurements of the ocean surface made by Skylab and GEOS-3 altimeters will be compared to theory and numerical models. Discrepancies arising from these comparisons shall be accounted for through the efforts made under this plan. Model improvements will be made. Sea surface topography including the geoid will be improved as a consequence of computing detailed gravimetric geoids from the combination of satellite-derived gravity fields with (1) global surface gravimetric data, (2) Skylab and GEOS-3 altimetry data, and (3) GEOS-3 and Apollo-Soyuz satellite-to-

satellite tracking (SST) data. The expected accuracy of the global gravimetric geoid will be 5 meters with 500 km horizontal resolution. Addition of altimeter data from advanced missions such as Seasat I will further improve the geoidal accuracy from 1 meter to 1 decimeter.

**W77-70424** **161-03-04**
Wallops Station, Wallops Island, Va.
**OCEAN DYNAMICS CIRCULATION MODELLING**
N. E. Huang 804-824-3411
(161-03-01)

The overall objective of this effort is to establish the feasibility of measuring current by remote sensing techniques. Specific objectives are: (1) to investigate and model the surface signature of ocean current systems through theoretical studies of current-wave interactions, surface topography changes due to geostrophic motions, and surface temperature characteristics, (2) to perform laboratory and field tests of physical models, (3) to verify or modify, if necessary, the physical models through results obtained from the laboratory experiments and the field tests, and (4) to develop and/or refine remote sensing techniques to provide inputs for the physical models. Through wave theory, the feasibility of using various wave-current interaction characteristics for current measurements will be studied continuously. A study of the surface temperature characteristics as an additional indicator of current boundaries will be initiated to provide independent data to check wave-current interaction results. Coordinated field studies from aircraft and ships will be conducted to validate the physical models and modify them if necessary. Concurrent with the progress of the theoretical and field studies, development of new uses of existing instruments and exploration of new remote sensing techniques will continuously be carried out in order to achieve the final goal of monitoring the global circulation pattern and providing all the needed inputs for the physical models from remotely sensed data.

**W77-70425** **161-03-05**
Langley Research Center, Langley Station, Va.
**GEOID DETERMINATION MODELING**
P. F. Holloway 804-827-2893

The utilization of satellite altimetry to determine temporal and spatial variations in the ocean's surface, requires a reference surface to which measurements can be compared on a near real-time basis. Such a surface is the geoid. However, considerable uncertainty presently exists concerning the Earth's geoid, primarily because the major data source for a fine-scale structural study of the geoid is land-based gravimetry data. Lack of sufficient data over the ocean areas introduces considerable uncertainties into the extrapolation of geoidal models over the ocean areas. Satellite tracking data provides only information on the long wavelength (4000 km) structure. Present uncertainties in the geoid range from 20 to 100 meters or more. The use of satellite altimetry data, combined with satellite tracking data and gravimetric data, can theoretically yield the shape of the geoid which is correct in scale, shape, and orientation to an accuracy of less than 1 meter. However, in order to take advantage of this theoretical capability, it will be necessary to develop precise mathematical theories and efficient computer algorithms for synthesis of the altimetry and gravimetry data. The purpose of this work is to develop mathematical models and efficient computer algorithms to permit the combination of available land gravimetry data with ocean altimetry data obtained from an orbiting spacecraft to an accuracy of less than 1 meter. This effort will also include the development of engineering programs to prove the validity of the mathematical models and algorithms.

**W77-70426** **161-03-06**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**OCEAN DYNAMICS RADAR SYSTEMS AND MODELING**
A. W. Newberry 213-354-7240

The thrust of this RTOP is to understand and model the imaging radar signature of ocean and polar ice patterns. This entails analyzing image formation of ocean waves and developing algorithms for the measurement of ocean wave height, waves energy spectra, and polar ice motion from the radar imagery. It also includes development of algorithms to derive wave directional spectra directly from the signal without generating an image. The ultimate objectives are to: (1) achieve a better understanding of the radar imagery obtained from space (SEASAT spacecraft), (2) verify a number of applications and (3) develop techniques which could be implemented on future spacecraft radar systems. Experimental aircraft radar data taken simultaneously with ground truth under different sea and weather conditons will be used to verify a number of models for the radar signature of ocean waves and polar ice. The same data will be used to check algorithms for the determination of wave height, wave energy spectra and global polar ice motion. The radar data to be used will consist of data already available from the Marineland and AIDJEX missions, and data which will be taken by the SEASAT ground Truth Experiment in the winter of 1977.

**W77-70427** **161-03-08**
Wallops Station, Wallops Island, Va.
**ADVANCED OCEANOGRAPHIC APPLICATIONS (ADA)**
H. R. Stanley 804-824-3411
(161-03-01; 161-03-04)

This effort is directed at the comprehensive development of ocean physics activities required for the Earth and Ocean Dynamics Applications Program (EODAP). As such, it has tentatively been dubbed "AOA" - Advanced Oceanographic Applications. Overall, its goals are those of EODAP: to identify, develop and demonstrate relevant remote sensing and data processing techniques that will contribute to the development and validation of predictive models for ocean-surface conditions and ocean circulation, and construction of an improved detailed marine geoid model. Through theoretical, laboratory and field experimental studies, coupled with satellite remotely sensed data, detailed physical models of the ocean will be developed so that the response of the oceans can be predicted based on a set of environmental conditions that can be monitored directly by, or extrapolated from, remote sensing methods. Modelling activities will be performed concurrent with the availability of the various input data and during the periods when the required theoretical or empirical relationships are also available. It is crucial to the modelling efforts that all macroscale data be compatible and that these data be provided by coordinated schedules of satellites and in situ observations; e.g., aircraft, ships, buoys, bottom-anchored instruments, etc. To further increase knowledge of macroscale processes, laboratory studies will be conducted to establish specific relationships under controlled conditions. All of these efforts will provide critical modelling information for the AOA.

**W77-70428** **161-03-09**
Wallops Station, Wallops Island, Va.
**NEW SENSOR AND INSTRUMENTATION DEVELOPMENT**
J. T. McGoogan 804-824-3411
(161-03-01)

The objectives of this project will be twofold: (a) to develop new active sensors such as the Wave Motion Sensor and new Holographic Radar for accomplishing the objectives of EODAP; (b) to bring the existing nanosecond radar, laser profilometer, AAFE radar altimeter, AAFE airborne oceanographic lidar, AAFE surface profile radar and other future AAFE and SRT instruments into a unified aircraft facility to provide a quick response facility for SEASAT-A and EODAP in general. Where possible, existing techniques and instrumentation will be utilized as the foundation for defining and studying new ocean surface active and passive microwave instrumentation, scattering theories, and onboard instrumentation for carrying out such studies.

**W77-70429** **161-03-14**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GEODETIC NETWORK DENSIFICATION USING RADIO MULTILATERATION**
A. W. Newberry 213-354-7240
(161-01-02; 369-02-08)

A need exists to develop an economic means for providing precise (1-5 cm) geodetic measurements on baselines in the 30 to 300 km range to complement the ARIES and LURE long-range systems which can accurately measure baselines 300 km or more, and existing and proposed systems geodolite short-range systems which provide accurate measurement on

baseline less than 30 km in length. Previous investigations have shown that this may be feasible by radio-ranging from a satellite--and/or aircraft-based system to a dense net of battery-operated ground transponders. A long range multiphase plan has been developed within this RTOP to achieve and implement this objective. The phases of this plan include: (1) preliminary theoretical and hardware analyses to verify the concepts, potential problem areas, and the potential user community and their requirements; (2) detailed systems analyses, hardware evaluation, software development, detailed system hardware design, and a cost/benefits analysis; (3) hardware development and aircraft system demonstration; (4) hardware modification for a satellite system, a satellite feasibility demonstration and operational system; and (5) exploitation of the system for the study of earth dynamics and geophysical phenomena. Continuous feasibility/cost/benefit evaluation of this project at each phase of development has been allowed for, to provide a continue/terminate decision at any stage.

**W77-70430** **161-05-06**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**CRYOGENIC GRAVITY METER DEVELOPMENT**
A. W. Newberry 213-354-7240

The objective of the investigation is to convert a current experimental cryogenic gravity meter into an operational instrument with a dynamic range of 10 to the 7th power and a sensitivity of 10 nanogal. Data records from the instrument will be analyzed for earth tides and for the spheroidal free oscillations of the earth which provide boundary conditions for models of the interior. The approach of the investigation is to complete the development of the instrument in a laboratory at Stanford University, and then to move and install it in a permanent observatory currently under construction at Del Puerto Canyon. Data will be recorded there digitally in an environment of low seismic noise, and the resulting records will be analyzed by spectral analysis techniques.

**W77-70431** **161-05-07**
Langley Research Center, Langley Station, Va.
**RADAR TECHNIQUES FOR OCEAN REMOTE SENSING**
W. L. Jones · 804-827-3631

The objective of this RTOP is to provide supporting research and technology for the development of advanced active microwave techniques for ocean remote sensing. This work is both experimental and analytical in nature and is for satellite and/or aircraft applications. For FY-77 the research is directed toward three major areas: (1) the measurement of ocean wave height and directional spectra, (2) the detection of ocean currents, and (3) the measurement of surface wind vector. For each of these areas, this RTOP provides total funding for the planning and execution of ocean remote sensing experiments (using aircraft, ocean towers and/or laboratory facilities) as well as experiment data reduction, analysis and reporting. In addition, it supports data reduction and analysis of data obtained during aircraft experiments in FY-76 (JONSWAP-75 and WISEX-76).

**W77-70432** **161-05-08**
Marshall Space Flight Center, Huntsville, Ala.
**CUBE CORNER RETROREFLECTOR TEST AND ANALYSIS**
J. D. Harper 205-453-1591

The objective of this RTOP is to test and analyze cube corner retroreflectors (CCR's). The study will produce data to describe the effect of physical parameters on the performance of the cubes. This data can then be used by NASA to select the correct configuration for future NASA Laser Ranging Programs. The Key elements of Laser Ranging Systems are: A laser(s), transmitting telescope(s), and a timing mechanism. These elements, when combined with the appropriate optics, electronics and mechanical structures, provide an accurate ranging system. Previous efforts have yielded systems that perform to moderate accuracies. As the accuracy requirements for the system increase, the parameters affecting the performance of the CCR's must be more precisely specified. Previous efforts have studied the performance of CCR's to prove that the design parameters were valid for that particular project. This study will use this information as a starting point and continue the testing and analysis to determine the effect of each physical parameter on the CCR operational performance.

**W77-70433** **161-07-01**
Goddard Space Flight Center, Greenbelt, Md.
**GEOPHYSICAL MONITORING BY SATELLITE RELAY (GMSR)**
R. J. Allenby 301-982-6523
(369-02-04; 161-08-01; 644-04-01)

This project proposes to: (1) develop and verify techniques for utilizing satellite relay systems for the collection of multipurpose geophysical data from field instruments in areas of potential earthquake hazard; (2) develop a Geophysical Data Collection Platform (GDCP), using microprocessor technology, for preprocessing and storing seismic and other geophysical data; (3) develop techniques for on-site compression, processing and analysis of high-bitrate data from seismometers without loss of meaningful information; (4) conduct experimental field operations using GDCP's in seismically-active areas of California, Alaska, and the Virgin Islands; and (5) collect geophysical data that will contribute to studies of earthquake mechanisms and prediction and the crustal structure of the eastern U.S. It will: (1) establish programs for developing a reliable system of recognizing seismic events from man-made and natural background noise, and for developing microprocessors and algorithms for pre-transmission compressing of this data; (2) develop geophysical instrument/DCP interfaces and establish prototype systems to verify satellite relay operations and to relay data from selected areas of tectonic interest; (3) develop and test a field-hardened GDCP; and (4) install and operate at or near Goddard a geophysical test station to aid in instrument design and testing and to obtain regional seismic information. The study is expected to produce a cost-effective technology, using DCP's and satellite relay, for preprocessing, collecting, and transmitting data from seismometers and other geophysical instruments installed in remote areas of high seismic risk. This technology, when fully developed, will be transferred to user agencies such as the U.S. Geological Survey and will contribute to earthquake hazard assessment programs, and to the ultimate goal of predicting the specific time, place, and magnitude of impending earthquakes.

**W77-70434** **161-07-02**
Langley Research Center, Langley Station, Va.
**COASTAL WAVE PREDICTION MODEL DEVELOPMENT**
P. F. Holloway 804-827-2893

This project aims to develop and validate modeling for use in advanced coastal wave prediction systems using SEASAT monitoring concepts. The approach is to complete development of an advanced coastal wave refraction model of the Baltimore Canyon region (boundaries match a future NOAA-NMC grid system). Clear-weather aircraft flights using photography and the laser profilometer will be conducted to obtain initial experimental data. Cloudy-weather aircraft flights using imaging radar will be conducted to obtain more adverse wave data. The experimental wave data will be compared with calculations from the computer wave model through simulation studies. The coastal wave modeling will be refined and integrated with NOAA deep-ocean forecast models to realize the potential for hurricane wave forecasts in the coastal zone. Aircraft and satellite experiments will be defined to test the integrated model system as part of an ASVT demonstration effort. The requirement for in situ data stations will also be examined. This is a joint activity with the NOAA Sea-Air Interaction Laboratory, the NOAA Weather Service Techniques Development Laboratory, with NOAA National Hurricane and Experimental Meteorology Laboratory, and the USACE Coastal Engineering Research Center.

**W77-70435** **161-08-01**
Goddard Space Flight Center, Greenbelt, Md.
**EARTH DYNAMICS DATA SYNTHESIS AND APPLICATIONS**
P. D. Lowman 301-982-2520
(369-02-04; 161-02-01; 369-02-01)

This effort aims to synthesize, interpret, and develop applications of EODAP data to global and regional investigations of the crust and upper mantle, to the assessment of earth

resources, and to the study of geophysical hazards. Previous interpretations of earth dynamics data have utilized single or closely related data types. Here, methods of joint interpretation involving many different types of data will be developed and utilized. The data base will include measurements of the gravity and magnetic field, geoid, surface position, crustal and earth motions, and surface topography. LANDSAT imagery and surface measurements will be utilized as needed. The project will be carried out jointly by the Geophysics, Geodynamics and Earth Resources branches of the Earth Survey Applications Division. Relevant satellite- and surface-derived geodetic, geophysical and geologic data will be compiled and cartographic techniques developed for representing different types of data on a common scale, using appropriate projections for world and regional maps. Quantitative and semi-quantitative methods will be developed for interpreting combinations of satellite and surface geophysical data such as magnetic anomalies, gravity anomalies, heat flow, and crustal thickness. Areas of particular interest, including North America, will be singled out for more intensive regional studies, and possible applications to economic mineral or oil exploration will be investigated. LANDSAT imagery will be studied in combination with geophysical data to delineate presently inactive or unrecognized plate boundaries. Expected results are: (1) practical applications of EODAP data to resource assessment and understanding of geophysical hazards, (2) global geophysical atlas and (3) Symposium on Space Science and Global Tectonics to be held in late 1978; proceedings to be published.

**W77-70436** **161-08-02**
Marshall Space Flight Center, Huntsville, Ala.
**SHUTTLE TETHERED SUBSATELLITE SYSTEM - REQUIREMENTS AND ANALYSIS**
M. A. Page 205-453-2858

The overall objectives of this effort are to: (1) determine the impact of application and engineering experiments and mission requirements on the tethered subsatellite, and (2) ascertain the effects of these requirements on the tether system. Feasibility of the tether concept will be determined by MSFC and the results will be used as the starting point for defining various tether systems. This effort will be concentrated on the accommodation of the application and engineering experiments and missions as defined by the users. The impact of these requirements on the tethered subsatellite will be determined. Requirements to integrate the instruments with the subsatellite will be investigated and the subsatellite defined. Emphasis will be placed on the initial requirements for gravity and magnetic field measurements missions as defined by the users. Coordination will be maintained with other studies to identify the total tether system.

## Weather and Climate

**W77-70437** **175-10-10**
Ames Research Center, Moffett Field, Calif.
**SEVERE STORMS AND LOCAL WEATHER RESEARCH**
D. R. Chapman 415-965-5065
(175-30-40)

The objective of this project is to investigate the utility of combining satellite observations with mesoscale meteorological numerical modeling for the study of nonviolent weather phenomena and, secondarily, of local air pollution effects. In addition, the applicability of the mesoscale model in the study of boundary layer parameterization for global weather and climate models of the troposphere and stratosphere will be investigated. The mesoscale model simulates atmospheric boundary layer behavior by numerical integration of the primitive equations on a three-dimensional grid with synoptic boundary conditions aloft and surface boundary conditions below. Physical forces presently incorporated in the model include advection, diffusive turbulence, subsidence, buoyancy, Coriolis, IR flux divergence from water vapor, thermal wind and pressure accelerations. The model will be used this year to: (1) study the dynamic behavior of a variety of three-dimensional problems of interest, (2) run sensitivity studies on model parameters and boundary conditions by means of a model output statistics approach, (3) carry out preliminary studies of its possible use in conjunction with the VISSAR Demonstration Project at GSFC, and (4) study dynamic synoptic/meso-scale interactions by using MESO-MET to formulate responsive boundary layer parameterizations and to incorporate these in the GISS nine-level global model.

**W77-70438** **175-10-30**
Langley Research Center, Langley Station, Va.
**SEVERE STORMS AND LOCAL WEATHER RESEARCH**
P. F. Holloway 804-827-2893

The purpose of this effort is to assess the application of remotely-sensed data to theories and numerical models for the movement, growth, and behavior of severe local storms. Development of the present Langley models to determine analytic and numerical solutions for the movement, growth, and behavior of thunderstorms, tornadoes, and hurricanes will continue. These solutions will be validated with aircraft and satellite data and applied in the study of the storm structure. Work conducted under this RTOP will be coordinated closely with related efforts at GSFC/GISS, ARC,and MSFC.

**W77-70439** **175-10-40**
Goddard Space Flight Center, Greenbelt, Md.
**SEVERE STORMS AND LOCAL WEATHER RESEARCH**
W. E. Shenk 301-982-5948
(175-10-70; 175-10-30)

This RTOP supports the Severe Storm Research Program and, in turn, the end objective entitled 'Disaster.' It proposes to: (1) develop improved objective methods for detecting and predicting severe storms and mesoscale phenomena, (2) obtain a better understanding of storm dynamics, (3) specify new satellite capabilities for detection and understanding of these phenomena. Measurements of severe storms and mesoscale phenomena and their environments will be synthesized and studied using numerical and statistical models wherever possible. The measurements will be obtained from satellite, aircraft, and conventional sources. Special processing systems will be used to extract parameters to be used in models. New aircraft sensors will be developed and tested to provide new or improved data. The results of various research approaches will be synthesized for a systems approach to the problem of severe storm detection and prediction. The expected results are: (1) collection of the most complete and correlated set of data, particularly measurements from space observation platforms, for application to studies of severe storms, (2) new techniques for extracting vital parameters, (3) development and testing of sensors to provide new data, especially from satellites, (4) verification or rejection of hypotheses on the structure and dynamics of severe storms leading to a better understanding of them, and (5) improved objective methods of detection and forecasting severe storms using modeling techniques.

**W77-70440** **175-10-50**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SEVERE STORMS AND LOCAL WEATHER RESEARCH**
D. P. Burcham 213-354-3028
(645-30-02)

This RTOP includes two tasks utilizing passive microwave techniques for atmospheric remote sensing of severe storms and local weather. (1) The existing SMILE (Scanning Microwave Inversion Layer Experiment) instrument which is the modified engineering model of the Nimbus-F Scanning Microwave Spectrometer, will be used to measure liquid and water vapor content in the lower 5 km of the atmosphere. In addition to demonstrating the accuracy with which ground-based microwave techniques can measure atmospheric water content (by comparison with coincident radiosonde measurements), the SMILE measurements will provide information on the formation of stratus cloud layers and the spatial and temporal spectrum of atmospheric turbulence in the Los Angeles basin. (2) The Shuttle Imaging Microwave Systems (SIMS), now in late definition phase at JPL, will provide global measurements of atmospheric water vapor, liquid water, and some information on drop size distribution, all with horizontal resolution of approximately 3 km. This horizontal resolution is an order of magnitude improvement over prior experiments, and will allow detailed measurements of the

dynamics of water in storm systems leading to an improved understanding of the formation and evolution of storm and hurricane systems. This task, by numerical simulation and liaison with active atmospheric research and meteorological groups, will develop a program for utilization of the SIMS to improve understanding of storm and hurricane dynamics.

**W77-70441** **175-10-70**
Marshall Space Flight Center, Huntsville, Ala.
**SEVERE STORMS AND LOCAL WEATHER RESEARCH**
R. E. Smith 205-453-4175
(645-10-01)

This effort proposes to: (1) provide scientific support for the Atmospheric Cloud Physics Laboratory, (2) determine the effects of spatial and temporal changes in atmospheric parameters on the dynamic properties of severe storms, (3) develop a system for measurement of atmospheric velocity flow fields associated with severe storms, and (4) assess the feasibility of using Doppler measurements of the ionosphere as a technique for predicting severe storms. The approach is to (1) develop theoretical concepts of atmospheric cloud microphysical processes, conduct experimental simulations of these microphenomena, and determine scientific functional requirements for the Atmospheric Cloud Physics Laboratory; (2) develop theoretical models of mesoscale systems using available data as inputs; (3) modify MSFC developed clear air turbulence measurement system to measure severe storms velocity fields; and (4) establish correlation between severe weather activity and observed perturbations in ionosphere.

**W77-70442** **175-20-30**
Langley Research Center, Langley Station, Va.
**MICROWAVE TECHNIQUES FOR METEOROLOGICAL RESEARCH**
C. T. Swift 804-827-3631

The objective of this work is to investigate the applicability of microwave/millimeter wave techniques in the study of the sea-air interface. The research will concentrate on radiometer hardware performance and radiometric data analysis and interpretation. The approach to the hardware phase is to develop near octave bandwidth, swept frequency microwave, and millimeter wave radiometers having low noise characteristics for use on aircraft and space shuttle. The approach to the analysis is to conduct controlled laboratory experiments and to utilize aircraft data for establishing a unique correlation between the radiometric signature and the physical characteristics of the wind-driven ocean surface. This work will provide techniques for measurement and separation of surface parameters. For example, the isolation of the emission from ocean foam will yield independent measurements of surface temperature and surface wind speed.

**W77-70443** **175-20-40**
Goddard Space Flight Center, Greenbelt, Md.
**METEOROLOGICAL PROCESSES RESEARCH**
John S. Theon 301-982-5249
(175-10-40; 175-30-40; 175-40-40; 175-50-40)

This study seeks: (1) to improve remote sensing techniques for observing meteorological and climatological parameters; (2) to develop, test, and calibrate new remote sensors required for such observations; (3) to demonstrate the applications of data from satellites such as Nimbus and SMS to the solution of meteorological and climatic problems involving multiple spatial and temporal scales; and (4) to develop and test diagnostic and prognostic models of meteorological and climatological phenomena. Numerical models of radiative transfer processes involving gaseous and particulate constituents, polarization, reflection, absorption, and transmission in the atmosphere will be developed from ground-based, balloon, aircraft, and satellite data. These models will seek to improve remote sensing of the atmospheric temperature and moisture, sea surface temperature, ocean roughness, surface winds, cloud physical parameters and snow and ice cover. Models including feedback mechanisms will be developed and tested to examine the importance of various parameters in determining the climate of the earth. Systems to support the required aircraft and spacecraft sensors will be provided. Laboratory facilities to calibrate, test, and evaluate remote sensors will be supported. Satellite data will be analyzed to provide a data base for multiscale meteorological models. The expected results are: (1) improved temperature profile inversions; (2) new and improved aircraft measurements of sea surface temperature and roughness and cloud physical parameters; (3) models to assess climate parameters; and (4) precipitation atlases for 1975-76 derived from ESMR data.

**W77-70444** **175-30-40**
Goddard Inst. for Space Studies, New York.
**STUDIES IN THE APPLICATION OF SATELLITE DATA TO LONG-RANGE FORECASTING AND CLIMATE PREDICTION AT COLUMBIA, CUNY, AND NYU**
M. Halem 212-678-5618

The general objective of this research program is to develop methods for the acquisition and analysis of meteorological satellite data and its application to short- and extended-range forecasting, and to studies of climate change. This RTOP is primarily to guide and support GISS, researchers and research efforts. Part of the program covered by the RTOP involves grants to New York-area universities for work in direct support of GISS meteorological projects. The work is performed on GISS premises by advanced graduate students and research associates from the universities involved, working under supervision of members of the GISS staff holding adjunct faculty appointments. These research assistants and associates make up the on-site junior-level scientific staff at GISS. Major projects conducted jointly with nearby university personnel under this RTOP include: (1) sounding technique development; (2) development of initialization and balancing scheme for the assimilation of satellite sounding data; (3) evaluation of sounding impact tests; (4) analysis of climate satellite data; (5) stochastic dynamic forecasts (monthly) from climate data sets; (6) studies of feedback mechanisms leading to droughts and deserts; (7) physics of atmosphere-ocean interactions; (8) development of stable numerical integration schemes for climate prediction. The on-site collaboration between New York-area universities, and GISS provides the high-level scientific expertise required to carry out the program objectives laid out in the GISS 5-year meteorological plan.

**W77-70445** **175-30-41**
Goddard Space Flight Center, Greenbelt, Md.
**SOUNDING TECHNIQUES FOR GLOBAL FORECASTING**
W. L. Barnes 301-982-4117
(175-10-40; 175-20-40; 175-30-40; 175-40-40)

Developing and testing the next generation of meteorological sensors using the most recent advances in theory and technology is the objective of this effort. Work will be concentrated on advanced atmospheric temperature sounders. A feasibility study for a polar orbiting sounder with spectral resolution of less than or equal to 0.1 cm to the minus one power will be conducted in-house. Certain critical components for such a sounder will be examined in the laboratory. Theoretical calculations will be made to demonstrate the capabilities of active (lidar) techniques for temperature and water vapor sounding. Contract research into the use of infrared heterodyne radiometry (IHR) for high spectral resolution synchronous-altitude sounders will be continued. The RTOP supports the following major programs: (1) daily weather forecasting, (2) severe storm research, and (3) long range weather forecasting. These in turn support the following end objectives: (1) food resources, (2) disaster, and (3) climatology. Expected results are (1) design for a high spectral resolution temperature sounder, (2) preliminary design of an IHR sounder for synchronous altitudes, and (3) feasibility of using lidar for temperature and water-vapor sounding.

**W77-70446** **175-30-50**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GLOBAL WEATHER RESEARCH**
D. P. Burcham 213-354-3028
(175-40-50)

This research is geared to acquiring a detailed understanding of the exchange of heat (both latent and sensible) and momentum between the atmosphere and a snow cover and the use of that knowledge in parameterizing that interchange for a general circulation model (GCM) of the atmosphere. The study expects

to include all heat transfer mechanisms at the surface, i.e. the conduction of heat through the snow into the ground, the turbulent exchange of heat from the surface, the radiation balance in the atmosphere above the snow and at the snow surface, and the latent heat transfer through evaporation and melting of snow. This involves a detailed numerical model describing the above processes and field observations using the JPL - developed micrometeorological instrument system.

**W77-70447** **175-40-10**
Ames Research Center, Moffett Field, Calif.
**CLIMATE RESEARCH, WITH EMPHASIS ON STRATOSPHERIC PERTURBATIONS**
D. R. Chapman 415-965-5065
(176-10-11)

Long range goal of this research is to assess the sign and magnitude of climatic variations induced by changes in the amount of various atmospheric aerosols and trace gases, and in the solar spectrum. The effects of both natural and man-made perturbations will be considered. Emphasis will be placed on perturbations occurring in the stratosphere. A combination of laboratory and aircraft measurements, theoretical modeling, and comparison with records of past climatic variations will be utilized to assess the possible climatic effects of contaminant emissions into the atmosphere. Laboratory and aircraft measurements will be made of the radiative properties of candidate contaminants. These include the specification of the optical properties of aerosols of interest. The theoretical modeling includes the development of radiation and dynamical models that will be applied on local, regional, and global scales. Studies of records of past climatic change, as illustrated by the investigation of polar ice cores, will supply clues to the causes of past climatic change, as well as permit an assessment of the models. The use of remotely sensed parameters in the climatic models will be stressed, and techniques will be developed to determine some of the important model parameters by remote sensing measurements. The sensitivity of the models to variations in the parameters they utilize will be assessed.

**W77-70448** **175-40-30**
Langley Research Center, Langley Station, Va.
**CLIMATE RESEARCH**
P. F. Holloway 804-827-2893
(683-75-32)

This research project has a twofold objective: to study requirements for measurement of albedo and longwave radiative energy emitted by the Earth-atmosphere system, and to understand radiative transfer processes of these quantities through sensitivity studies as an aid in determining the Earth's energy budget. The first phase of the study will investigate measurement techniques, determine sampling strategy, and develop data reduction and analysis techniques for Earth Radiation Budget measurements. These techniques will be used to specify an optimum satellite system for obtaining Earth Radiation Budget data on regional, zonal, and global scales. The radiative transfer investigation explores the sensitivity of the outgoing longwave radiation at the top of the atmosphere to some of the more important parameters and assumptions inherent in radiative transfer models which will be used for future application to more comprehensive global climate models. The major uses of the data are (1) climate models, (2) atmospheric physics or understanding the physical basis of climate, and (3) statistical studies or climate diagnostics.

**W77-70449** **175-40-40**
Goddard Space Flight Center, Greenbelt, Md.
**CLIMATE RESEARCH**
Donald F. Heath 301-982-6421

The objectives of this study are: (1) development of climatological atlases of the stratospheric ozone fields in conjunction with dynamical analyses to be used as benchmark standards for the inference of long term trends for the period from solar maximum to solar minimum, (2) measurements of solar spectral irradiance and investigations of the intrinsic variability of the sun and corresponding atmospheric responses and global scale, and (3) investigation of large scale stratospheric processes and long term solar variability with regards to the evaluation of input parameters for climate models. BUV ozone data gathered over a 6-year period will be reduced and analyzed. A climatological atlas of the stratosphere based upon stratospheric ozone, temperature, derived wind and transport calculations for the investigation of large scale stratospheric processes and the inference of long term trends in the global ozone distribution will be produced. Improve the ozone inversion processes and the information retrieved from the BUV stratospheric ozone soundings will be improved. The intrinsic variability of the sun as a climate model parameter will be investigated. This RTOP supports: (1) climate research, (2) pollution monitoring, (3) long range weather forecasting, and (4) stratospheric research. These in turn support the end objectives: environment. The expected results are: (1) production of a climatology of the stratosphere, (2) new information on the intrinsic variability of the sun, (3) production of a new radiation standard to improve the radiometric accuracy of sun from 160nm to lower wavelengths, and (4) new information for input parameters to General Circulation Models.

**W77-70450** **175-40-50**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**CLIMATE RESEARCH**
D. P. Burcham 213-354-3028
(175-30-50)

The objective of this study is to provide quantitative measures of certain parameters which determine energy exchange at the Earth's surface. The factors addressed by this investigation are surface albedo and latent heat. The extent and duration of snow and ice cover are known to be among the most important variables in the Earth's heat balance due to their substantial impact on albedo. Changes in the ice and snow cover can have a significant effect on weather and climate. Both snow and ice cover and frozen ground are important determinants of latent heat exchange. Operational satellite data will be utilized to quantitatively describe surface albedo in areas affected by snow and ice. Thermal data will be used to monitor the condition of frozen ground. The facilities of JPL's Image Processing Laboratory will be used to analyze available satellite data (primarily NOAA) to quantify these variables. Attention will be devoted to achieving a better quantitative understanding of snow and ice maps published in the past, and currently on an operational basis. JPL's Portable Field Reflectance Spectrometer (PFRS), a unique portable instrument for obtaining spectra in the wavelength region of .45 to 2.5 microns, will also be used to study the albedo characteristics of snow under a variety of environmental conditions. This data could be significant in the design of the future satellite instruments. This study is undertaken in cooperation with Dr. George Kukla of the Lamont-Doherty Geological Observatory of Columbia University.

**W77-70451** **175-40-60**
Wallops Station, Wallops Island, Va.
**CLIMATE RESEARCH - OZONE MEASUREMENTS**
A. C. Holland 804-824-3411
(175-40-40; 175-40-70)

The objective of this project is to improve techniques for measuring atmospheric ozone. The approach is to: (1) study improvements in optical methods for measuring atmospheric ozone using Monte-Carlo simulation of radiative transfer through the atmosphere, assess errors or limitations in measurements due to scattering and/or absorption by molecules and aerosols, perform studies to determine optimum instrument design parameters with necessary design modifications to satisfy future requirements for routine synoptic measurements of ozone; (2) perform evaluation and intercomparison of satellite-borne, aircraft-based, balloon-borne and ground-based sensors for the measurement of ozone, determine the degree to which these different techniques are capable of giving consistent results, and (3) use the ground-based, balloon-borne and aircraft-borne ozone measurement systems to provide correlative (including in-situ) truth data for the calibration and validation of rocket and satellite borne ozone sensors. The expected results are improvement of ozone measurement systems.

**W77-70452** **175-40-70**
Marshall Space Flight Center, Huntsville, Ala.
**CLIMATE RESEARCH (GEOPHYSICAL FLUID DYNAMICS)**
George H. Fichtl 205-453-0875

This climate research effort has as its objective the development of scientific concepts and experimental techniques to support the development of shuttle/Spacelab payload laboratory-scale experiments for exploration of (1) the basic processes that govern and determine the planetary scale motions of the earth's atmosphere and (2) the dynamics of these motions. The program is designed to provide the necessary scientific support required for the Phase A, B, C/D efforts on the Atmospheric/Oceanic Circulations/Experiments Laboratory (AOCEL) as well as individual geophysical fluid dynamics (GFD) experiments for the shuttle/Spacelab. The approach to the effort shall be accomplished by a balanced effort involving theory and experiment. The research will center on the theoretical and experimental applications of the GFD concept first proposed by Prof. Hart of the University of Colorado. To accomplish these objectives, the following activities will be performed: (1) electroconvection theoretical predictions and ground-based experiments, (2) experiment perturbation analysis, and (3) MSFC dishpan experiments. These activities will be supported by a National Research Council (NRC) fellow. The resources for the NRC fellow will be obtained from this RTOP funding.

**W77-70453** **175-50-40**
Goddard Space Flight Center, Greenbelt, Md.
**PROGRAMMATIC SYNTHESIS AND AUGMENTATION**
E. A. Neil 301-982-6291

The objective of this RTOP is to provide financial support to the NASA Meteorology Program Office (MPO) in the conduct of its business in support of the Office of Applications and the various program offices represented. Results of efforts under this RTOP will be used in performing evaluations, providing recommendations, and developing future plans for NASA's Weather and Climate mission and programs. Funding will be utilized in-house and through available support services contractors for selected efforts in fulfilling the objectives of the MPO as defined in its charter. Studies will be focused on emerging technology so as to expedite its application and on future requirements so as to identify areas requiring initiation of new technology development. Technical and programmatic conferences as required from time to time by NASA Headquarters will be arranged and supported, and information resources to support program planning/evaluation activities will be developed and maintained. Additional funds to RTOP's requiring augmentation and for other programmatic requirements to meet changing national or Agency needs, priorities and programs are provided.

**W77-70454** **175-51-91**
John F. Kennedy Space Center, Cocoa Beach, Fla.
**THE APPLICATION OF REMOTE SENSING TO EVALUATING SURFACE TEMPERATURES DURING FREEZING CONDITIONS**
Paul D. Toft 305-867-7705
(663-70-91)

The primary objective of the investigation is to establish a cost effective remote-sensing method to accurately determine with greater resolution than current techniques provide, the amount of crop freeze exposure over large geographical areas, and to develop geoatmospheric models of Florida's citrus areas for accurate freeze exposure forecasting. The approach selected utilizes airborne and satellite thermal data to measure the earth-air interface temperatures over selected agricultural areas during freeze conditions. These improved geoatmospheric models (radiation balance models) would be used to provide more effective and timely decisions concerning the freeze protection required for agricultural crops under freezing or near freezing conditions. Investigations and modeling efforts will also be directed toward determination of the effect of cultural practices in groves, lake warming (lake effect) and utilization of various freeze protection techniques upon crop freeze exposure. The results of this work will be applied directly by the Florida Freeze Warning Service (NOAA) in their freeze forecasts and will be transferrable to other regions where critical temperature forecasting problems exist.

## Pollution and Monitoring

**W77-70455** **176-10-11**
Ames Research Center, Moffett Field, Calif.
**STRATOSPHERIC MEASUREMENTS AND ANALYSIS PROGRAM**
D. R. Chapman 415-965-5065
(175-40-10; 198-10-04; 198-30-02)

The objectives are: (1) to measure the distribution and variations of stratospheric constituents and to help establish their stratospheric background levels; (2) to analyze and interpret aircraft and satellite data and to evaluate adequacy of existing techniques; (3) to permit simultaneous measurements of additional species on the U-2 aircraft so as to better utilize U-2 flight time; (4) to develop strategy for conducting stratospheric surveys so as to provide maximum data utilization at minimum cost; and (5) to measure and characterize the properties of stratospheric aerosols. The approach is to continue U-2 meridional and seasonal aircraft surveys and coordinate them with other survey programs such as GASP, Nimbus G, or programs in support of space shuttle; to utilize stratospheric chemical transport and radiative balance models for interpretation of aircraft, balloon, and satellite data, and improve model validation; to develop integration hardware and utility services for multiple experiments aboard the U-2 aircraft; to develop sampling strategy by studying requirements and capabilities and utilizing workshops and consultants; and, finally, to continue the collection and measurement of stratospheric aerosol samples.

**W77-70456** **176-10-31**
Langley Research Center, Langley Station, Va.
**DEVELOPMENT OF LIMB SOUNDING AND OCCULTATION TECHNIQUES FOR STRATOSPHERIC MEASUREMENTS**
J. E. Stitt 804-827-3745
(176-40-31)

The objective of this work is to improve our knowledge of the stratosphere by developing advanced sensors to obtain global surveys of the stratospheric distribution of gaseous and particulate constituents important to climate and ozone depletion chemistry. The work will be directed at providing sensors to obtain preliminary data as early as possible for shuttle flight missions of opportunity. The utility of adapting existing AAFE-LACATE sensor hardware for shuttle use will be investigated. A plan for adapting the hardware to use either a Vuilleumier (VM) or Annabel detector cooler, and to improve reliability and radiometric performance will be developed. The feasibility of obtaining a measurement of stratospheric methyl-chloride (CH3CL) using the HALOE gas-filter correlation sensor approach will be studied and design requirements for implementing this measurement in a HALOE sensor will be established. With this addition, the HALOE will also provide measurements of the largest known natural stratospheric chlorine source. Conceptual design will be developed for improved Stratospheric Extinction Radiometer (SER) to measure stratospheric aerosols and ozone using SAGE technology. Ozone extinction cross-section data in the Chappius band will be obtained for this work.

**W77-70457** **176-10-41**
Goddard Space Flight Center, Greenbelt, Md.
**ANALYSIS OF SATELLITE OZONE DATA AND DEVELOPMENT OF WATER VAPOR SENSOR TECHNIQUES**
Ernest Hilsenrath 301-982-5754
(176-10-11; 176-40-31)

The purpose of this study is to utilize existing 2-D photochemical models for the analysis and interpretation of satellite ozone data and temperature fields. An in-house model will also be used to further interpret significant geophysical phenomena relating to short term changes in stratospheric ozone. Techniques to measure atmospheric trace constituents important in ozone photochemistry will be developed. This development will be

restricted to the plasma probe and the 3-D quadrupole Mass Spectrometer utilizing an aircraft platform. 2-D models will be used with Nimbus 4 satellite ozone data (BUV) and temperature data (SCR) to test temperature dependence of model photochemistry. Satellite and rocket data will then be imputed to perform specific theoretical experiments. Laboratory experiments to determine sensitivity and specificity to various trace gases will be performed. Breadboards will be fabricated demonstrating performance in flight conditions. Results expected are: (1) operational use of models to study geophysical phenomena, such as stratospheric warmings, solar-terrestrial phenomena and pollution effects will begin and (2) breadboard or laboratory instruments to measure trace constituents in lower stratosphere from aircraft platforms will be developed.

**W77-70458** **176-10-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**INTERFEROMETER AND MICROWAVE TECHNIQUES FOR STRATOSPHERIC MEASUREMENT**
D. P. Burcham 213-354-3028
(198-10-06)

This RTOP describes the objectives and plans for two separate ongoing activities which have been combined into one funding unit at the request and for the convenience of the NASA Office of Applications. For clarity, the tasks are discussed separately in each paragraph of the RTOP. Remote sensing techniques are required for the determination of stratospheric trace gas composition. In order to employ such techniques at infrared wavelengths in a stratospheric measurements program, fast Fourier spectrometer for aircraft and balloon observations (to be made under the Measurements Program, RTOP 198-10-06) are being developed. The new infrared instrumentation, the Mark II interferometer, will cover the wavelength region from 2 to 14 microns at an ultimate spectral resolution of 0.002 cm with an energy throughput which permits spectral observations of the sun at sunrise or sunset to be made in time intervals of 100 seconds. From these data mixing ratios and mixing ratio altitude profiles of many of the important stratospheric trace molecules as e.g. O3, HCl, HF, HBr, ClO, H2CO, NH3, CH4, CO, CO2, NO, NO2, N2O as well as their isotopic variants can be obtained with typical sensitivities down to 10 to the minus 12th power. In support of the microwave observations and the MLS program, a millimeter spectrometer is being put into operation, utilizing microwave radiometer components. The spectrometer whose present frequency range covers the 100 to 200 GHz region will be used in the initial stages of the task to measure accurate line shapes and intensities of the O2 lines and specifically the ClO lines near 167 GHz under conditions typical of the stratosphere. The frequency range of the spectrometer will be continuously extended as part of this laboratory support program.

**W77-70459** **176-10-61**
Wallops Station, Wallops Island, Va.
**DETECTION, CHARACTERIZATION AND ANALYSIS OF ATMOSPHERIC AEROSOLS**
A. C. Holland 804-824-3411
(176-10-31; 176-40-31)

The objective of this RTOP is to develop the analytic techniques necessary to interpret remotely sensed data on the atmospheric aerosol, and the models necessary to evaluate the impact of atmospheric aerosols on the earth's albedo. Models of radiative transfer through the earth's atmosphere for both plane wave and finite beam illumination will be developed and tested. The model atmospheres used will be (1) plane-parallel, stratified and (2) spherically symmetric, stratified models. These simulations will be used to determine the best strategies for the remote detection of atmospheric aerosols using both passive and active techniques. The models will be used further to calculate the effect of varying amounts of atmospheric aerosols on the earth's radiation budget.

**W77-70460** **176-20-31**
Langley Research Center, Langley Station, Va.
**REMOTE MEASUREMENT OF TROPOSPHERIC POLLUTANTS**
P. F. Holloway 804-827-2893
(176-20-32; 176-40-31)

The objective of this RTOP is to evaluate the role and capabilities of airborne and spaceborne remote sensors for monitoring air quality on urban-to-global scales. Measurement technology development is the major portion of the current tropospheric program. The sensor development work begins with the definition of observables (e.g., spectral characteristics and radiative models) and proceeds through evaluation of measurement concepts and techniques applicable to both aerosol and molecular pollutant monitoring. Emphasis in aerosol measurements will be on improvement of inversion schemes for the visual polarization measurement technique and the solar aureole technique. Molecular trace constituent sensor work will emphasize passive techniques such as the gas filter correlation analyzer and correlation interferometer instruments and the total gas burden.

**W77-70461** **176-20-32**
Langley Research Center, Langley Station, Va.
**DEMONSTRATION TESTING OF TROPOSPHERIC SENSORS ON URBAN AND REGIONAL SCALES**
P. F. Holloway 804-827-2893
(176-20-31; 176-40-31)

This RTOP will (1) demonstrate the capability of remote sensors for detecting, mapping, and tracking tropospheric pollution on urban to regional scales, (2) evaluate the role of remote sensors in integrated monitoring systems, (3) develop the capability for providing ground truth for eventual satellite measurements and (4) develop a systematic approach for evaluating remote sensor candidates for future missions. Tests of available remote sensor concepts in conjunction with user agencies and the scientific community will be conducted. Remote sensor test will be evaluated and correlated with in situ support data. Systems studies will be conducted to evaluate the eventual role of remote sensors in urban and regional monitoring systems.

**W77-70462** **176-20-41**
Goddard Space Flight Center, Greenbelt, Md.
**PASSIVE REMOTE SENSING CONCEPTS FOR PROFILING TROPOSPHERIC POLLUTANTS**
C. L. Korb 301-982-6233
(176-20-31; 176-20-51; 176-20-32)

The objective of this RTOP is to develop and evaluate a new atmospheric pollution monitoring experiment, the Differential Correlation Radiometer (DCR), which will provide the capability for measuring vertical pollutant concentration profiles and near surface concentrations for the major tropospheric pollutants. The experiment will be able to perform profiling from satellite or aircraft as well as from ground stations. The approach utilizes the high spectral resolution DCR technique operating in the reflected solar infrared to obtain measurements in different portions of the atmospheric line profile. These measurements are then inverted to obtain pollutant vertical concentration profiles. Because the reflected solar infrared region is used, the measured data are relatively independent of environmental variables such as surface temperature, and atmospheric temperature profile. To implement this experiment, a field model will be developed and evaluated to test the concept of atmospheric concentration profiling; analytical studies and laboratory measurements will be made for data interpretation purposes; and, an aircraft unit will be developed and evaluated. This RTOP supports tropospheric and stratospheric pollution monitoring and the end objective: protection of the environment. Expected results are the development of an ultrahigh sensitivity satellite experiment for the measurement of tropospheric vertical pollution profiles; and the development of the analytic techniques required for data analysis and interpretation.

**W77-70463** **176-20-42**
Goddard Space Flight Center, Greenbelt, Md.
**MODELING OF TROPOSPHERIC POLLUTION TRANSPORT**
Richard W. Stewart 212-678-5579

The objectives of this research are to utilize mathematical models: (1) to aid in the interpretation of remotely sensed data on atmospheric composition and to assist in establishing sensor requirements for future experiments, and (2) to assess

the impact of aerospace and industrial activities on the atmosphere. The approach is to develop analytic and numerical models for the description of phenomena related to atmospheric pollution. These models are presently concerned with urban and regional scale effects and will be made increasingly comprehensive as those dynamic and thermal properties of the atmosphere which influence the composition of polluted air are included in the computational procedures. Expected results include: (1) development of a reacting plume dispersion model for powerplant siting applications, (2) development of improved models for statistical interpretation of remotely sensed data, and (3) assessment of the environmental impacts of selected industrial activities and of the efficacy of alternative control strategies.

**W77-70464** **176-20-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**LASER TECHNIQUES FOR TROPOSPHERIC POLLUTION SENSING**
D. P. Burcham 213-354-3028

This task covers the development and evaluation of both active and passive instruments which use infrared laser and heterodyne receiver technology. Improved infrared spectra will be obtained with laser sources and used to determine how well an airborne laser absorption spectrometer (LAS) will be able to produce altitude profiles of several important constituents (e.g. O3,H2O, NO, NO2). Ground-based laser instruments will be used to monitor ozone, nitric oxide, and hydrocarbons over horizontal and vertical paths in the JPL ambient atmosphere, with emphasis on evaluating instrument sensitivity to various degrading factors. Speckle fluctuations and their effect on the sensitivity of an active instrument such as the LAS will be investigated.

**W77-70465** **176-30-21**
Lewis Research Center, Cleveland, Ohio.
**ANALYSIS AND INTERPRETATION OF REMOTELY SENSED GREAT LAKES WATER QUALITY DATA**
H. Mark 216-433-4000

This effort proposes to develop various methods and systems for monitoring water quality and other limnological parameters in the Great Lakes using remote sensing data. The ultimate goal is to develop realistic systems using data from satellites such as LANDSAT and Nimbus G. A main criterion is that the methods and systems be made available to the user agencies for needed operational surveillance of the Great Lakes. The radiative transfer equation will be used to model the backscatter of sunlight from water bodies containing suspended particulate and dissolved solids of several species. The model will then be used to relate water parameters of importance to remote multispectral data. Other tasks involved are: (1) completion of the analysis and documentation of spectral signatures of soil types characteristic of those remaining after strip mining operations and delineation of those which lead to acidic runoff, (2) analysis of existing data and additional aircraft multispectral scanner data as required to show that spectral signatures can be used to define soil types which are producers of high acidic runoff from strip-mined areas, (3) documentation of results, (4) evaluation of benefits to state users, and (5) definition of sensor characteristics for meeting user monitoring requirements.

**W77-70466** **176-30-31**
Langley Research Center, Langley Station, Va.
**SENSOR EVALUATION AND DEMONSTRATION FOR MONITORING OF OCEAN DUMPING**
P. F. Holloway 804-827-2893
(176-30-32; 177-55-31)

The objectives of this RTOP are: (1) to develop and evaluate remote sensing techniques for the detection and monitoring of pollutants dumped into coastal waters; (2) to develop a plan for focusing remote sensing technology on ocean dumping problems (NOAA); and (3) to initiate planning for an ASVT for ocean dumping monitoring. Existing and new research will continue to be focused toward the development of techniques for using remote sensed data to measure parameters relevant to monitoring of pollutants dumped into oceans. A joint plan will be developed and implemented with NOAA and other users to apply NASA technology to the monitoring of ocean dumping activities. The determination and application of spectral signatures of ocean-dumped pollutants, such as acid, sewage sludge, and toxic chemicals, will continue. Laboratory analysis of dumped materials and studies of the effects, if any, of chemical reactions on interpretation of remote sensed data will also continue. Overflights will be performed with existing remote sensors to evaluate their use in this specific monitoring task. These flights will be coordinated with detailed in situ measurements and with laboratory studies. Analysis and documentation of results from 1975 joint field experiments with both NOAA and EPA will be completed. Planning will be initiated to develop an ASVT for ocean dumping monitoring.

**W77-70467** **176-30-32**
Langley Research Center, Langley Station, Va.
**COASTAL ZONE INVESTIGATIONS FOR ENVIRONMENTAL BASELINE MONITORING**
P. F. Holloway 804-827-2893
(176-30-31; 177-55-31)

These investigations will: (1) focus research activities on the application of remote sensing techniques for establishing an environmental baseline and monitoring environmental effects of offshore development; (2) develop techniques to monitor and quantify circulation features, water mass distributions in coastal regions, and pollutant transport and dispersal; (3) determine spectral signatures of pollutants and environmental baseline materials in coastal waters; (4) evaluate existing remote sensors for baseline measurements and to establish requirements for the design of new instruments and the development of improved techniques; and (5) develop algorithms and data analysis and interpretive techniques to prepare data products for users. The approach is to: (1) analyze results from a joint NASA/EPA field experiment to monitor an industrial effluent, (2) define specific parameters to establish a coastal zone environmental baseline, (3) perform laboratory upwelled radiance measurements on selected pollutants to support development of data analysis algorithms and verification of existing theoretical optical models, (4) determine spectral signatures of various natural environmental parameters, including phenomena associated with red tide organisms, (5) conduct field activities to verify laboratory and model results, (6) continue development of 3-D circulation and pollution dispersion models, (7) investigate application of advanced remote sensing techniques for water quality, and (8) perform laboratory studies to determine feasibility of microwave sensing of water pollutants.

**W77-70468** **176-30-41**
Goddard Space Flight Center, Greenbelt, Md.
**RED TIDE & COASTAL ZONE WATER CHARACTERISTICS**
W. L. Barnes 301-982-4117
(177-44-41)

The objective is to develop techniques for using ocean color remote sensing to detect, identify and quantify pollutants and harmful organisms, such as red tide, in coastal waters. Field investigations will be carried out combining ship and aircraft observations wherein simultaneous surface truth measurements and remote sensing are carried out. Spectrometers and multispectral imaging radiometers will be flown on aircraft in selected coastal areas, such as the New York Bight and Gulf of Mexico, concurrent with surface measurements of such parameters as transmissivity, scattering and phytoplankton type and concentration. Comparison of the surface truth data with the remotely sensed data will be made to develop optimum data processing techniques for extraction of the desired parameters, e.g., type of red tide organism and concentration, type of pollutant and concentration, from the remotely sensed data. This RTOP supports the CZCS on Nimbus G. This, in turn, supports the end objectives of identifying pollutants and tracing their movements with the CZCS on Nimbus G and with the aircraft scanner. The expected results are a set of characteristic signatures that will allow pollutant identification from remotely sensed data and algorithms for quantifying pollutants in water.

**W77-70469** **176-30-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**EPA/JPL LAKE CLASSIFICATION RESEARCH PROJECT**

D. P. Burcham 213-354-3028
(177-66-11; 176-95-01)

JPL and the Environmental Protection Agency (EPA) will conduct investigations to determine the usefulness of LANDSAT MSS data as a means of classifying the trophic conditions of lakes. This research is being undertaken with a long term goal of providing state and Federal agencies through EPA, NASA, or JPL a means of classifying lakes. Under the requirements of PL 92-500, the Federal Water Pollution Control Act (FWPCA), [Sections, 106, 208, 304, 305, and 314] each state must establish and submit to the EPA (Regional Administrator) an identification and classification of the trophic condition of subject water bodies. This requirement exists in order for states to receive grants for water pollution control programs as well as lake restoration. It is clear that the responsibility for lake classification rests with the individual state. The establishment of criteria and the approval of methods and procedures for trophic classification resides with the EPA. The EPA wishes to continue this research in order to evaluate satellite and/or aircraft classifications as a cost effective, semiquantitative alternative to present manual methods. JPL and EPA will coordinate their activities for water samples, water spectrometer signature data and LANDSAT MSS data acquisition and analysis. Data will be obtained as close to the LANDSAT overpass time as possible at fixed locations on the subject lake. Classifications by water sample analysis and by LANDSAT MSS analysis will be made and compared to the spectral signatures for known classes of water. The fixed stations on the lake will be mapped on each LANDSAT image so that multispectral training and resulting classification will be closely tied to the actual site of water and spectroscopic point of acquisition. Modelling experiments will be undertaken using the MSS data to predict those substances and processes which effect water quality. This work will support investigations being proposed by Ames Rsearch Center RTOP (1177-66-11), definition of an ASVT for Trophic Classification of Lakes for Public Law 95-500 purposes.

**W77-70470** **176-30-61**
Wallops Station, Wallops Island, Va.
**WATER POLLUTION**
A. C. Holland 804-824-3411

The objective is to develop the analytic techniques necessary to interpret remotely sensed data on water quality and water pollution, and to provide the laboratory data necessary to those analytic techniques for proper evaluation of remotely sensed data. Existing radiative transfer models developed under other RTOPS to describe remote sensing of atmospheric parameters will be modified and extended to describe transfer through an air-water interface and through turbid water. The models will incorporate a rough water surface and an ocean bottom surface of arbitrary depth and reflectivity. These models will be used for determining the best strategies for the remote detection of water quality and water pollution. Where necessary, laboratory measurements will be performed to provide qualitative input data for the models.

**W77-70471** **176-40-31**
Langley Research Center, Langley Station, Va.
**DEVELOPMENT OF TECHNIQUES FOR INTERPRETATION AND UTILIZATION OF REMOTELY SENSED ATMOSPHERIC CONSTITUENT DATA**
P. F. Holloway 804-827-2893
(176-20-31; 176-20-32; 176-10-31; 683-75-33)

The objectives of this RTOP are related to in situ and remotely sensed data for the stratosphere and troposphere and are: (1) to develop data analysis techniques for extracting information from satellite-borne sensors such as those on NIMBUS-G and AEM-SAGE, (2) to statistically correlate data obtained from ground, airborne, and satellite-borne platforms to extract the maximum amount of information, (3) to define radiative transfer characteristics and develop improved techniques for calculating radiative transfer in the stratosphere taking into account chemical reactions and transport processes, (4) to apply estimation theory in conjunction with simulation models to the analysis, interpretation, and utilization of urban air quality measurements (CO and SO2) from remote and in situ sensors, and (5) to use analytical models to define requirements and sampling strategies. The approach will be to (1) establish the user's requirements for data and species, accuracy, and spatial and temporal resolution, (2) collect and correlate all available atmospheric constituent data, (3) use these data to create an interim reference stratosphere, (4) apply stratistical analysis and parameter estimation techniques to establish sampling requirements and strategy in both troposphere and stratosphere, (5) maintain close liasion between sensor scientists and numerical modeling specialists, and (6) utilize the research and graduate study program which has been established at LaRC in conjunction with GWU, which is being funded under this RTOP solely for support of elements of the Environmental Quality Monitoring discipline. The emphasis of this work will be in the analysis and utilization of satellite derived data.

**W77-70472** **176-40-41**
Goddard Space Flight Center, Greenbelt, Md.
**EVALUATION OF PATTERN ANALYSIS TECHNIQUES TO INVESTIGATE ANTHROPOGENIC ATMOSPHERIC OZONE CHANGES**
Ernest Hilsenrath 301-982-5754
(176-40-31)

The objectives are: (1) to evaluate the application of pattern analysis and statistical techniques to the detection and discrimination of acthropogenic ozone changes and its application for monitoring and decision making, and (2) to define a measurement system with the necessary sensitivity and resolution to detect anthropogenic changes and establish a procedure for early detection of these changes. Existing and proposed satellite measurement capabilities for ozone, models that predict dispersion of catalytic agents, and existing ozone data will be examined in conjunction with conventional pattern recognition techniques. Development models and statistical techniques to account for natural variability and select ozone changes due to known perturbations to evaluate pattern analysis system will be used. The study will result in the definition of a measurement system capable of discriminating ozone changes due to anthropogenic sources. This will result in the establishment of the required detection limits and discrimination to specify a monitoring program. Mechanisms for early detection of ozone changes will be established which will ultimately provide strategy for control and regulation.

**W77-70473** **176-56-91**
John F. Kennedy Space Center, Cocoa Beach, Fla.
**APPLICATION OF REMOTE SENSING FOR PREDICTION AND DETECTION OF THERMAL POLLUTION**
Roy A. Bland 305-867-7705
(663-70-91; 177-22-91)

A generalized analytical three-dimensional math model is being developed which will predict the motion, extent, duration, and temperature of thermal plumes within the waters into which they are discharged. The math model, whose parameters are supplied by remote sensing and in situ measurements, is presently being applied to Biscayne Bay, Florida, which is a shallow lagoon and to St. Luci nuclear power plant (near Stuart, Florida) which discharges onto the continental shelf. Also work is presently being initiated on application of the model to a deep inland reservoir at Lake Belews, NC, in a parallel effort with the Duke Power Company. In the final phase of this effort, for which this funding is proposed, the math model will be generalized to apply to power plants which discharge into any type of water body.

**W77-70474** **176-90-31**
Langley Research Center, Langley Station, Va.
**COORDINATION AND PLANNING ACTIVITIES FOR THE ENVIRONMENTAL QUALITY PROGRAM**
P. F. Holloway 804-827-2893

The purposes of this RTOP are: (1) to continue the Focal Center planning and coordinating activities for Environmental Quality, (2) to explore with user agencies cooperative programs that will utilize NASA's expertise in the area of pollution monitoring, (3) to conduct economic studies with emphasis on stratospheric research and future polluting, monitoring missions, (4) to continue the existing agreement between NASA Langley and the Region VI Virginia State Air Pollution Control Board, (5) and to continue supporting Headquarters-OA with technical

assistance involving preparation of material for the annual congressional testimony for the agency's Environmental Quality Programs, and preparation of material in support of New Start Programs. Additionally, Langley plans to prepare a tropospheric research plan which will essentially address the same questions as was covered in the Stratospheric Research Program plan approved by the Associate Administrator for Applications during FY-75. This RTOP is also intented to cover the extensive coordination activities required between this office and other Lead Centers, i.e., ERTS follow-on evaluation, Aircraft Support requirements and participation in the many inter-agency working groups and committee (e.g.; ICMSE, ICMAREP, COSPAR, ICAS, ICCERSP) involved in Environmental Quality Programs.

## Earth Resources

**W77-70475** **177-10-81**
Lyndon B. Johnson Space Center, Houston, Tex.
**EARTH RESOURCES SURVEY SYSTEM AND PROGRAM DEFINITION STUDIES**
George A. Nixon 713-483-3751

The ERPO of JSC in performing its lead center functions for the NASA Earth Resources Program is responsible for overall program coordination and integration. In order to accomplish these tasks and establish meaningful goals and objectives, effective system and program definition studies must occur on an almost continual basis. It is the purpose of this RTOP to provide the funding to supplement and complement the ERPO and to assure the ERPO of quick reaction study capability.

**W77-70476** **177-20-81**
Lyndon B. Johnson Space Center, Houston, Tex.
**MULTISENSOR CORRELATION AND APPLICATION ANALYSIS**
A. W. Patteson 713-483-4506

The objective is to develop methods for modeling and correlating multisensor data sets both spatially and temporally to provide additional information channels for improving classification accuracy and in some cases, permitting classification. A parallel objective is to enable applications analysis to determine the most effective multisensor system for particular earth resources applications. Initial work would be a continuation of sensor (currently multispectral scanner/thematic mapper) modelimg and parametric analysis initiated in FY76 under UPN 177-42-85-24 (UPN 177-20-XX-03 herein). Active and passive microwave imagers would be modeled for parametric analysis with multispectral scanners starting in FY78. FY77 work would also provide methods for merging quantitative microwave digital imagery with visible, IR and thermal IR digital imagery to provide information channels for improving classification accuracy, crop condition assessment, crop inventory and all weather performance. Elimination of manual or partially manual registration would be emphasized. This technology development would permit the merger of LANDSAT AND Seasat imagery in the 1978 time frame and also multispectral optical/multifrequency radar digital imagery in the Shuttle era for earth resources applications. Microwave signature measurement work in RTOP 177-44-83 indicates the utility of microwave data for multichannel classification. Extensive work with LANDSAT and other optical multispectral data has indicated the power of classification techniques in the visible, near IR, and thermal IR spectral areas.

**W77-70477** **177-22-41**
Goddard Space Flight Center, Greenbelt, Md.
**VISIBLE AND IR SENSOR SUBSYSTEMS**
Harvey Ostrow 301-982-4107

The objective of this effort is to develop the technology required for the development, calibration, and performance characterization of advanced visible and IR sensors that will be flown in future earth observation survey missions. High spatial and spectral resolution image sensors require new development in a number of areas that will be addressed in this RTOP. Several types of advanced detectors will be developed and evaluated, including: (1) linear photodiode and CCD detector arrays for pushbroom scanners, (2) HgCdTe/CCD hybrid arrays and pyroelectric arrays for operation in the emissive IR region, and (3) TDI arrays for signal-to-noise ratio improvement applicable to the Thematic Mapper. To improve the radiometric accuracy of sensors such as the Thematic Mapper, stable calibration lamps will be developed along with large aperture ground calibration sources. A system for image sensor simulation will be completed for sensor optimization and cost reduction studies. The RTOP supports the following major programs: (1) Earth Resources Survey, (2) Landsat, (3) Thematic Mapper, (4) Shuttle and Spacelab payloads. These in turn support the following end objectives: (1) food resources, (2) mineral resources, (3) environment, and (4) disaster. The expected results are development of visible and IR linear detectors arrays for high resolution, multispectral pushbroom scanners, TDI detectors, precision space and ground calibration sources, and a sensor simulation and optimization system to conduct advanced design studies.

**W77-70478** **177-22-83**
Lyndon B. Johnson Space Center, Houston, Tex.
**MULTICHANNEL AIRCRAFT SCANNER**
J. E. Kessel 713-483-2497

The objective of this RTOP is to reconfigure the Johnson Space Center 24-Channel Scanner into a versatile, reliable, fast reaction, multispectral data collection system. Projected uses include verification or definition of new applications, and employment as a research tool in the optimization of spectral bands in connection with the definition of new sensors. Included in the scope of the RTOP will be the generation of an overall plan for exploration of the UV-reflective-IR regime for across-the-board applications. The system would provide a research tool for evaluation of the utility of proposed channelizations and characteristics of proposed scanner system designs. The 24-Channel Scanner Baseplate, including optics and possibly detectors will be retained in the proposed reconfiguration. State-of-the-art integrated circuit and microprocessor techniques will be employed to simplify data handling and formatting. Simplifications will be incorporated to limit data collection recording to up to 12 of the total number of channels, resulting in reduced complexity in data processing providing for broader user participation. The net result of these changes will be a more flexible and reliable system providing a much needed research tool, as well as providing for highly specialized data acquisition for targets of local and international interest.

**W77-70479** **177-22-91**
John F. Kennedy Space Center, Cocoa Beach, Fla.
**LASER SYSTEM REMOTE SENSOR FOR SUBSURFACE SEA TEMPERATURE AND TURBIDITY**
Roy A. Bland 305-867-7705
(176-56-91)

This RTOP is proposed to continue a development program for a laser system which will ultimately be employed as a remote sensor to obtain subsurface temperatures and turbidity profiles and other data in fresh and marine waters. These profiles will be obtained from the measurements of the shifted and unshifted wavelength radiation returns due to the Raman, Brillouin and Tyndall phenomena. All components of this system obtained under this present RTOP funding will compose an integral system suitable for operation from a surface vessel. Initial experiments will be performed with the laser system as it is being completed and after completion the laser system will undergo a thorough testing in natural water. The design of the system to be used as a Sea Surface Laser Probe (SSLP) will, in all aspects, consider reuse of components when the final phase, termed the Airborne Laser Probe (ALP), is undertaken.

**W77-70480** **177-23-42**
Goddard Space Flight Center, Greenbelt, Md.
**APPLICATION OF IMAGING RADAR FOR WATER RESOURCE**
V. V. Salomonson 301-982-6481
(683-75-31; 177-51-41; 177-54-41)

The objectives of this effort are to definitize the design parameters for a synthetic aperture radar (SAR) applicable to

monitoring parameters of importance for water resources management and to confirm the expected performance by analyzing active microwave data for the TDS/Water Resources Shuttle Mission. Ground-based radar and airborne SAR experiments will be conducted to observe the temporal variation of soil moisture. In addition, radar data will be used to characterize the runoff potential for watersheds and validate its applicability for flood mapping. The following approach will be taken to accomplish the aformentioned objectives: (1) obtain repeated ground based active microwave backscatter measurements over a sustained period of time; (2) study the data obtained by an airborne imaging radar system and scatterometer and relate them to soil moisture measurements at a given location and flooded area (targets of opportunity); (3) derive the correlation between observed radar return and measured runoff coefficients and see if the potential runoff for small watershed can be objectively defined in this manner. It is expected that the potential for obtaining useful hydrological measurements from a spaceborne, single frequency, SAR will be established. In addition, the particular desirability of having repeated SAR observations from the TDS over a given location for the purpose of objectively and comprehensively monitoring soil moisture, runoff potential, and mapping floods should be confirmed.

**W77-70481** **177-23-81**
Lyndon B. Johnson Space Center, Houston, Tex.
**SHUTTLE IMAGING RADAR**
H. A. Nitschke 713-483-3073
(645-30-07)

The objectives of this plan are to complete the studies for an imaging radar for the Shuttle to finalize the design, and prepare procurement specifications of the system. In meeting these objectives, trade-off analyses were conducted to determine the several radar configurations which meet the different scientific applications. The relationship of this work to other programs, such as AAFE, were also considered. Alternate concepts were considered. Preliminary design and specifications were developed for the most promising configurations. Preliminary plans for implementation, including cost and time factors, were developed along with the technical requirements. During development of the preliminary design and specification for the recommended radar configurations, several areas requiring further development were established. These results, along with the results to be obtained from the tasks to be accomplished as part of RTOP 645-30-07 for FY77, must be analyzed, evaluated, and incorporated into a specification for procurement of flight hardware. This specification and verification of the system baseline parameters must be completed during FY77 to support a FY78 new hardware start.

**W77-70482** **177-28-51**
Goddard Space Flight Center, Greenbelt, Md.
**SPECIALIZED MULTISPECTRAL IMAGING AND ANALYSIS SYSTEM**
Harvey Ostrow 301-982-4107
(177-22-41; 177-44-41; 177-51-41; 177-54-41; 177-53-41)

The objective is to provide a flexible and low cost high spatial and spectral resolution aircraft imager to obtain data for determining and testing remote sensing requirements in a variety of earth resources discipline studies. An existing linear detector array pushbroom scanner developed in RTOP 177-22-41 will be modified for flight on the NASA Convair 990. This scan technique can simultaneously provide high spatial resolution and high signal-to-noise ratio data, thus making the sensor suitable for economically obtaining data for a variety of earth resources disciplines. Spectral filters will be easily changeable to satisfy mission requirements. For example, for coastal zone oceanography applications, very high spatial resolution images (i.e., 20 meters) will be obtained in 20-nanometer channels while meeting SNR requirements. Data for agricultural use will be obtained at very high SNR's. Such data will permit an assessment to be made of the value of very high SNR on classification accuracy, as well as studies of the trade-offs between SNR and resolution. These tests will be defined and the results evaluated by Goddard's Application discipline scientists in agriculture, landuse, water, mineral and marine resources. The expected results are: (1) a flexible and economical aircraft multispectral imager will be provided; (2) the potential advantages of the pushbroom array scanner will be determined; (3) the effects of high SNR data on crop classification accuray will be evaluated; (4) the interrelationship of critical sensor parameters such as SN and resolution will be determined. This type of data could significantly impact future sensor design.

**W77-70483** **177-28-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SPECIALIZED MULTISPECTRAL IMAGING AND ANALYSIS SYSTEM**
D. P. Burcham 213-354-3028

The long term objective is to produce a 4-band multispectral camera utilizing CCD arrays which will have a real-time data processor attached. The processor produces a film image on which is superimposed, pixel by pixel, the output of a target discriminator. The filters as well as the data selection algorithm will be selectable. A major objective for the coming FY is to obtain aircraft operational experience with the line array camera-processor system constructed during FY-76. This system will be flown over target areas in known mineralized areas. The goal is to discriminate areas of hydrothermal alteration from other rocks in the field of view. Knowledge will be gained on the SMIAS output discriminator levels, their positioning and the ability to use the same settings in different geographical areas as well as under different lighting conditions. Other objectives for FY-77 are to: (1) improve the optics design; (2) add a strip film recorder, whereas at present the data can only be photographed from the monitor; (3) participate in the Convair 990 SS2 test flights; and (4) begin a system design for a CCD area array camera.

**W77-70484** **177-32-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GEOPHYSICAL/GEOLOGICAL MODEL DEVELOPMENT**
D. P. Burcham 213-354-3028

During FY-76 the Image Processing Laboratory (IPL) at JPL has developed prototype software which enables the synthesis of images of potential fields. It is possible to create gray scale force field imagery developed from (1) a model of a potential field (such as gravity, magnetism, or heat flow) or (2) true exploration data which exists as widely spaced point measurement or as gridded data. The gridded or point data has typically been displayed as contour data which are interpreted as lines of equal force or intensity. We propose to construct subsurface geologic structural models, depicting buried intrusives and/or other structural disturbances. Simulated gravity, magnetic and thermal anomalies associated with these models will be synthesized and displayed as multi-level gray scale imagery. Methods and procedures will be developed for converting simulated field measurements to gray scale imagery. Techniques will be developed to analyze the spatial and frequency relationships between gravity, magnetic and heat flow anomalies in the model. It is expected that analysis and display of the force field imagery as a function of color will be aided through the use of the Image-100. Utilization of VICAR subroutines for traditional methods of potential field analyses will be assessed. It is expected that through the use of models, tools will be developed for processing these types of data; methods, procedures and insights into the future processing of actual field data will be possible. These techniques may have applications to geothermal exploration since known geothermal areas are often associated with such a combination of field anomalies.

**W77-70485** **177-32-84**
National Space Technology Labs., Bay Saint Louis, Miss.
**DATA COLLECTION SYSTEM TECHNOLOGY APPLICATIONS AND SYSTEM ENHANCEMENT**
Robert Hegwood 601-688-2125
(656-42-02; 177-32-71)

The objectives of this RTOP are (1) to conduct demonstration projects to accelerate the adoption and application of space program derived Data Collection systems (DCS) technology by regional and resident agencies at the National Space Technology Laboratories (NSTL) in fulfillment of their missions. Regional

application demonstration projects will be conducted with the States of Mississippi (Pearl River Basin), Louisiana (Atchafalaya River Basin), and Tennessee (Tennessee Valley Authority); and (2) to continue enhancement of the NSTL Satellite Data Acquisition and Processing System (SDAPS) through low-cost modifications to provide expanded capabilities for LANDSAT and GOES data collection systems. The approach will use NSTL capabilities in data collection systems technology to accelerate users' adoption and application of such technology. These capabilities include the facilities and personnel to perform the functions of: (1) Project and Systems Management; (2) Systems Analysis and Project Engineering; and (3) Technical Liaison with Public Sector Users, and other related functions. Plans for projects will be submitted to the Office of Applications for approval.

**W77-70486** **177-42-11**
Ames Research Center, Moffett Field, Calif.
**LARGE-SCALE EARTH RESOURCES DATA PROCESSING**
D. R. Chapman 415-965-5065

The purpose of this work is the development and maintenance of computer software in support of the processing of LANDSAT data on ILLIAC IV and other computer systems. Particular emphasis will be placed on continuing system software development and support of the expanding efforts of other cooperating user agencies. Current work with the University of Illinois Center for Advanced Computation will provide the base for large-scale data handling and processing of the type required for earth resources data processing.

**W77-70487** **177-42-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**MINERAL EXPLORATION**
D. P. Burcham 213-354-3028

The primary objective is to improve and develop techniques for applying remotely sensed multispectral data to mineral exploration. Using a data base of spacecraft, aircraft and field-acquired multispectral digital data, computer processing with image analysis will be used to solve particular geologic problems. Specific objectives will be to: (1) develop and analyze techniques for identifying sandstone-associated uranium deposits in Wyoming in conjunction with the U. S. Geological Survey and the University of Wyoming, (2) continue mineral exploration work with Bolivian government for tin and copper deposits, (3) complete the study of alteration zones associated with an unmined prophyry copper deposit in Arizona, in conjunction with the Continental Oil Company with specific attention given to the problem of vegetation, (4) compare planned Thematic Mapper parameters with MSS performance to quantitatively determine relative usefulness of Landsat-C follow-on for geologic applications, (5) develop recommendations for Rocksat, (6) evaluate application of L-band radar for geologic mapping and identification of hydrothermal alteration zones using existing computer processing techniques, (7) apply existing processing techniques to simulate land uses of Seasat radar, and (8) analyze field and laboratory data to derive and interpret the mineralogical information contained in the combination of all sources of multispectral data, including visible, thermal, and microwave.

**W77-70488** **177-42-86**
Lyndon B. Johnson Space Center, Houston, Tex.
**LARGE-AREA CROP PRODUCTION INVENTORY ACREAGE ESTIMATION**
A. L. Grandfield 713-483-2071
(177-42-86)

The Large-Area Crop Inventory Experiment (LACIE) has uncovered a number of problems related to agricultural machine inventory methods. These problems can be grouped under the functional areas of signature extension, classification, crop area estimation, and image interpretation. General objectives for obtaining solutions in these problem areas are as follows. In signature extension the objective is to develop a statistical sampling strategy for picking a small number of training segments that will suffice for classifying a large area. In classification the objectives are to improve classification accuracy when only one temporal Landsat pass is available through the use of a per field classifier and to develop improved clustering techniques. In crop area estimation the objective is to develop regression-type estimators to remove bias and variance in the current LACIE area estimator due to the fact that sample segments are not reallocated each year, due to classification error, and due to low confidence segment area estimates. Finally, in image interpretation the objective is to develop improved image interpretation methods, for using multitemporal imagery. Here improvements are sought from the use of single images which have been generated from a set of date-specific images using feature extraction-type linear transformations.

**W77-70489** **177-42-87**
Lyndon B. Johnson Space Center, Houston, Tex.
**LARGE AREA OF CROP PRODUCTION INVENTORY YIELD ESTIMATION**
A. L. Grandfield 713-483-2071
(177-42-87)

One part of the LACIE (Large Area Crop Inventory Experiment) is devoted to the estimation of wheat yield. LACIE wheat yield models were derived by regressing average state yield on trend and weather related variables. Evaluations of these models have indicated that for years with abnormal weather yield estimation errors are large. This research effort is in part aimed at developing yield models that are more responsive to weather fluctuations. Specifically the research is centered around developing yield estimation methods based on the variables transformed vegetation index (TVI) and leaf area index (LAI). Values for both variables can be obtained from Landsat data. One variable that is needed to estimate point-yields is the surface air temperature. Consequently, another part of this research effort will investigate the accuracy of satellite-derived surface air temperatures. A third area of interest in the LACIE is the biometeorological time scale of a crop called the crop calendar. The LACIE crop calendar model does not contain precipitation (or soil moisture) terms and consequently when started with planting dates it tends to misestimate winter wheat emergence dates. Thus, another part of this research effort will consider evaluation of improved crop calendar models. Finally the last research effort in this RTOP will be devoted to extending the LACIE technology to estimate yields of other crops including corn, soybeans, and rice.

**W77-70490** **177-42-88**
Lyndon B. Johnson Space Center, Houston, Tex.
**SUPERSITE DATA ACQUISITION AND MANAGEMENT**
Leo F. Childs 713-483-4776
(177-42-85)

The objectives included in the FY-77 RTOP 'CALL' is a considerable number of RTOP's which require multispectral sensor data and supporting ground truth. The 'CALL' recommends that to conserve resources, data collected over the LACIE supersites should be used whenever possible. The objective of this RTOP is to establish a source of calibrated multispectral and ground truth data required by the EOD RTOP's and to support other NASA centers RTOP's under UPN 177, 175 and 663. The current LACIE Field Measurements Project, which is collecting data over LACIE supersites will be expanded to include the data from JSME and other RTOP's. These data will be verified as to quality, reformatted, correlated, and stored in the LACIE field measurements data band. Multifrequency RADAR data will also be acquired and stored in the facility. Calibrated data sets will be cataloged and made available to all specified users.

**W77-70491** **177-43-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ERS SUB-PIXEL CLASSIFICATION AND SPECTRAL RESOLUTION STUDY**
D. P. Burcham 213-354-3028

On-board data analysis and pattern recognition offer a means of data compression that will render high resolution sensor data rates compatible with existing communication channel capacity. This research is a continuation of an effort to demonstrate the utility of spacecraft data processing techniques to extract information from high resolution imagery. The specific objectives are two-fold: first to demonstrate the utility of intra-pixel texture measurements and the corresponding texture image as a descriptor in the same sense as a spectral band; and second, to demonstrate

the utility of information derived from a cluster analysis of high resolution intra-pixel information, particularly with regard to area measurement accuracy. Candidate data processing techniques will be delimited to those with flight application potential. These objectives will be realized within the context of three specific applications: land use, crop census and yield (area), and forestry (species determination). High resolution underflight data will be scanned and digitized. Texture will be measured for regions that correspond in size to one LANDSAT picture element. The same sub-pixel information will be subjected to a cluster analysis. The 'texture' images and the cluster analysis information (number of clusters, relative number of members, principal signature) will be registered within the corresponding LANDSAT frame. The effectiveness of the texture channel will be demonstrated by a comparison of thematic maps generated by the JPL Bayesian classifier operating on spectral information and spectral information plus the texture channel. Information derived from cluster analysis will be evaluated relative to its impact on area measurement accuracy and classifier performance on LANDSAT resolution imagery.

**W77-70492** **177-44-41**
Goddard Space Flight Center, Greenbelt, Md.
**ATMOSPHERIC EFFECTS, HCMM MODELLING AND CZCS MODELLING**
W. L. Barnes 301-982-4117

The objectives of this RTOP are to develop software that will be used in processing and analyzing data from the HCMM and CZCS sensors, and to conduct field experiments to investigate techniques for identifying, quantifying, and correcting errors caused by atmospheric effects in optical remote sensing. Measurement of atmospheric degradation of remotely sensed images is primarily a problem of determining the aerosol optical thickness of the atmosphere. Consequently, a series of field experiments will be conducted to validate theoretical calculations of the feasibility of remotely sensing the atmospheric optical thickness using both passive and active techniques. Algorithms in support of the HCMM for determining thermal interia, soil moisture, and evapotranspiration will be completed and tested with high altitude aircraft data. Models being developed for use with CZCS will be refined further and tested by means of Ocean Color Scanner data. This RTOP supports the following major programs: HCMM, and CZCS. These, in turn, support the following end objectives: (1) thermal inertia mapping for surface composition identification, soil moisture measurement, plant stress detection and snow melt measurement for runoff prediction, and (2) Ocean color measurement for chlorophyll measurement for bioproductivity indication, sediment measurement, and salinity from gelbstoffe measurement. The expected results from the HCMM and CZCS investigations are data processing schemes to be applied to the spacecraft data. In atmospheric correction, some correction will be possible with passive radiometry only, but atmospheric observation to 10% will probably require laser sensing.

**W77-70493** **177-44-42**
Goddard Space Flight Center, Greenbelt, Md.
**HCMM AND CZCS SIMULATION**
W. L. Barnes 301-982-4117

The objective of this RTOP is to conduct a series of field experiments that will provide data for use in processing and analyzing data from the HCMM and CZCS sensors. The aircraft sensors, now flying, will simulate the CZCS and HCMR and will be utilized, together with other supporting sensors, to gather data in areas where the surface condition is well known in order to develop models that can utilize the remotely sensed data to accurately identify the surface character. This RTOP supports the following major program: HCMM and CZCS. This in turn, support the following end objectives: (1) thermal inertia mapping for surface composition identification, soil moisture measurement, plant stress detection and snow melt measurement for runoff prediction, and (2) ocean color measurement for chlorophyll measurement for bioproductivity indication, sediment measurement, and salinity from gelbstoffe measurement. The expected result from the simulator flights is a data base to be used by both government and civilian investigators for developing and testing algorithms to be used with the CZCS and HCMR.

**W77-70494** **177-44-43**
Goddard Space Flight Center, Greenbelt, Md.
**EARTH RESOURCES DATA INTERPRETATION TECHNIQUE DEVELOPMENT**
Pater A. Bracken 310-982-6989
(177-23-41; 177-61-42; 177-44-41; 177-41-42; 177-54-51; 177-52-41)

The objectives of this RTOP are: to develop data interpretation techniques and computer software to meet common data handling, processing, analysis, classification and output product generation requirements of earth resources studies within the Applications Directorate; to provide the common software needed to assess the utility of using satellite imagery; and to evaluate the accuracy of multispectral classification technqiues in agricultural, water resources, land use, census and geological investigations. The technical approach consists of developing techniques and computer software on the Goddard AOIPS and 360/91 computers to meet the common data handling, data analysis, and data interpretation requirements of Goddard Earth Resources RTOPs active during FY-77. Existing computer software will be enhanced and new data interpretation techniques will be developed to classify, cluster, correlate, overlay, display and manage image data from Landsat, HCMM, CZCS and aircraft sensors. Techniques and software will be developed to combine these data with maps, surface truth measures and other ancillary data to assess the utility of using satellite imagery and to evaluate classification accuracy in support of a variety of in-house earth resources investigations.

**W77-70495** **177-44-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SIMS EARTH OBSERVATIONS SRT**
D. P. Burcham 213-354-3028

Microwave radiometry has been proved a useful remote sensing tool for earth observations by the NEMS and ESMR experiments on NUMBUS-5 and S-193 and S-194 experiments on Skylab. These experiments have led to other microwave experiments developed for NIMBUS-F and now being developed for NIMBUS-G and TIROS-N. The shuttle, because of its extended capabilities over previous space transportation systems, offers a unique opportunity to significantly extend the developing applications of microwave radiometry. It can provide improved surface resolution at frequencies which have been used on prior experiments, and provide for meaningful measurements at lower frequencies which have not been feasible for previous experiments. Measurements with improved resolution and at longer wavelengths are especially useful for observing phenomena such as soil moisture, permafrost regions, ice boundaries in lakes and oceans, etc. The Shuttle Imaging Microwave System (SIMS), now in late definition phase will provide such measurements. This task will provide the supporting required for interpreting the SIMS measurements in terms of geophysical parameters, which are of interest for hydrology, geology, ship routing, and other applications. The research will include theoretical modeling and controlled experiments using existing instrumentation. In addition, this task will include the initiation of construction of an aircraft version of the SIMS experiment which utilizes the existing one-third scale model of the SIMS antenna.

**W77-70496** **177-44-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**THERMAL, HCMM**
D. P. Burcham 213-354-3028

The major objective of this study is the development of analysis techniques for thermal IR data to be acquired by the HCMM and other future high resolution thermal IR satellite systems. Based on experience gained from development of sophisticated and simple models, aircraft data analyses, and on-site experiments, the most practical data interpretation techniques for various geologic and soil moisture applications will be identified and made available. Thermal properties of the earth's surface such as thermal inertia, conductivity, and specific heat can be used in both geologic mapping and soil moisture mapping as a

complement to surface reflectivity data such as provided by Landsat. These thermal properties are not sensed directly but must be inferred from temperature measurement (by thermal IR sensors) made at various times in the diurnal cycle, combined with modeling of the surfaces heating processes. This study of the earth applications of thermal IR sensing by satellites will proceed as follows: (1) continuation of the development of thermal models on a theoretical basis to identify and account for the effects of topography, meteorological heating and cooling processes, clouds, vegetation, soil mositure and inhomogeneities, albedo and emissivity; (2) testing and improvement of the models by use of satellite, aircraft, and ground data to be collected for this purpose; (3) establishment of the utility of thermal data for geologic, soil moisture and possibly geothermal applications; and (4) investigation of the utility of thermal information of a less quantitative nature which can be derived without modeling from HCMM and future Landsat surface temperature data.

**W77-70497** **177-44-83**
Lyndon B. Johnson Space Center, Houston, Tex.
**MULTIFREQUENCY MICROWAVE CLASSIFICATION OF SURFACE AND SUBSURFACE OBSERVABLES**
A. W. Patteson 713-483-4506
(177-51-84; 177-44-82)

Extraction of qualitative information on agricultural and soil properties using data from microwave system has been demonstrated. The FY-77 effort will further quantify the response of active and passive boom-mounted and airborne active and passive microwave sensors to agricultural, forest, and soil moisture phenomena associated with both vegetation cover observables and soil properties (i.e., surface and subsurface observables) affecting the growth and yield of agricultural crops and forests; and the response of microwave sensors to the vegetation cover and conditions of interest. The overall objective is to develop techniques by which soil moisture profiles and key agricultural crop and forest phenomena can be accurately determined and/or differentiated by active and passive microwave sensors, as complimentary to and/or independent of other sensing technologies as deemed appropriate by cost/benefit factors. The soil moisture investigations are a continuation of those being conducted within the JSME (Joint Soil Moisture Experiment) using passive and active and airborne sensors. The JSME is directed toward defining optimal techniques for measuring soil moisture in support of user applications; for example, the input of JSME soil mositure data into LACIE (Large Area Crop Invenstory Experiment) yield models for crop yield determination over LACIE supersites.

**W77-70498** **177-44-85**
Lyndon B. Johnson Space Center, Houston, Tex.
**SENSOR AND MISSION PARAMETER EFFECTS ON CLASSIFICATION/MENSURATION**
Jay Harnage 713-483-6357

The objective of this task is to provide additional substantiation for the design of the Landsat Follow-on (LFo) Thematic Mapper and other future sensor system specifications. Sensor modeling and parametric analysis work initiated in FY-76 will be continued to determine sensor and mission parameter effects on classification/mensuration accuracy.

**W77-70499** **177 51-41**
Goddard Space Flight Center, Greenbelt, Md.
**REMOTE SENSING OF SOIL MOISTURE FOR WATER RESOURCES**
T. Schmugge 301-982-6507
(177-44-83; 177-44-41)

The objective is to study the use of microwave, both active and passive, and thermal IR techniques for the remote sensing of soil moisture for use in water resources and agriculture. The need is for the quantification of the limitations of these techniques, so that their usefulness can be assessed more accurately. It is expected that the radiometer data acquired by this effort will satisfy the requirements of the Joint US/USSR exchange agreement on the use of microwave radiometers for the remote sensing of soil moisture. An additional objective will be the study of the capability of microwave imagers for the characterization of watershed runoff coefficients. Analysis of data acquired during aircraft flights will be the primary approach. This will be supplemented by modeling efforts to estimate microwave brightness temperatures and backscatter coefficients for realistic moisture and temperature profiles under various surface conditions. A comparison of the modeling efforts with the aircraft measurements and the field measurements made by others will be performed. Included in the modeling efforts will be sensitivity analysis to determine the improvements that may be expected by the inclusion of remotely sensed soil moisture data into the watershed runoff and moisture budget models. Microwave radiometers data acquired by the Nimbus 5 and 6 satellites will continue to be analyzed for soil moisture features. The radiometer results from the 1976 spring and summer flight missions will be analyzed and compared with the expectations of our models. Additional data flights will be flown into the spring and early summer of 1977.

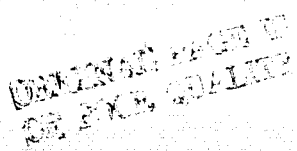
**W77-70500** **177-51-42**
Goddard Space Flight Center, Greenbelt, Md.
**SIMULATION STUDIES DEVELOPMENT OF INTERPRETIVE TECHNIQUES FOR THEMATIC MAPPER AND ADVANCED SENSORS**
S. G. Ungar 212-678-5603

The objectives of this program are to: (1) evaluate multispectral classification accuracies as a function of scanner performance parameter (spectral bands, spectral range, sensitivity and S/N ratio) for agricultural applications with special emphasis on classification and mensuration accuracies as a function of scanner resolution; (2) quantitatively evaluate the performance improvement expected with Thematic Mapper and LANDSAT-C; and (3) refine and improve current information-extraction techniques to take full advantage of potential increased capability introduced with Thematic Mapper and LANDSAT-C for agriculture, land use, water resources and geology. Techniques and software have been developed to simulate satellite observations of earth resources for up to 24 spectral bands. Band width, band placement, spatial resolutions, and various aspects of instrument response (see above) are specified for each study. The basic inputs to the simulation study consist of spectral signatures obtained by airborne instruments, such as the JSC 24-Channel Multispectral Scanner, and specification of atmosphere conditions. Varying atmospheric conditions may be simulated through GISS modeling programs. The software provides for reliable evaluation of classification results by direct comparison with computer-stored digital ground-truth arrays. Expected results include: (1) an evaluation of the effect of band size, band placement, spatial resolution and instrument performance parameters on crop-type discrimination with emphasis on the parameters proposed for LANDSAT-C and Thematic Mapper; (2) a realistic evaluation of the effect of varying atmospheric conditions on classification accuracy; and (3) the construction of new information-extraction techniques to exploit LANDSAT-C and Thematic Mapper and an evaluation of the improvement in acreage and yield estimates, and a minimization of ground-truth required to make regionally valid crop production forecast.

**W77-70501** **177-51-43**
Goddard Space Flight Center, Greenbelt, Md.
**AGRICULTURAL SENSOR PARAMETERS AND CLASSIFICATION**
J. L. Barker 301-982-4978

The objective is to identify optimum and recommended parameters for satellite sensing and monitoring of vegetation, especially crops. For the approach, there will be on-going interaction among application scientists, agricultural users, and sensor engineers to evaluate existing systems, simulate proposed images, evaluate products, and make recommendations. Major elements are to: (1) use existing scanner and ground observations from Prudue Data Band and others, (2) obtain polarized field spectra in visible through thermal IR of crops under controlled growth conditions in co-operation with Agricultural Research Center in Beltsville, Md. and (3) measure accuracy of aircraft, synthetic, and simulated digital data in an identical classifier which will vary: current and proposed sensor parameters, field parameters, orbital parameters, and processing parameters.





expected results include definition of sensor parameters necessary to monitor vegetation, and technical recommendations for aircraft and shuttle support of Earth Resources Missions on Landsat Follow-on, SEOS, HCMM, AEM, etc.

**W77-70502** **177-51-44**
Goddard Space Flight Center, Greenbelt, Md.
**YIELD MODEL DEVELOPMENT**
J. Price 301-982-4951
(175-20-40; 177-54-41; 177-51-41)

The purpose of this work is to continue the evaluation and development of geobased information systems, spectral-physiological crop growth simulation models, and soil moisture balance computational approaches that will lead to improved crop yields forecasts using satellite data. Existing knowledge and progress involving a moisture balance, geobased information system incorporating meteorological and earth resources satellite data so as to eventually estimate wheat yield will be further evaluated by applying this approach to another geographical region and crop growth situation (grain sorghum). Within the area encompassed by the geobased information system an existing grain sorghum crop growth model will be evaluated for its compatibility and responsiveness to direct inputs from earth resources satellite data and moisture-balance information from the geobased information system. Comparisons will be made at several locations between ground truth observations of sorghum growth, crop growth model results using traditional data inputs, and crop growth results using the geobased system and satellite data inputs. It is expected that the results of the efforts in this year will provide a better definition of the applicability of meteorological and earth resources satellite data for predicting crop growth and yield.

**W77-70503** **177-51-81**
Lyndon B. Johnson Space Center, Houston, Tex.
**FAP (FORESTRY APPLICATIONS PROJECT)**
A. W. Patteson 713-483-4506

The U. S. Forest Service and NASA/JSC/EOD supports the continued effort, in the FAP (Forestry Applications Project), for investigating and developing the use of Remote Sensing Techniques as a tool for performing Forest and Range Resource Inventories. In 1974, Congress passed Public Law 93-378, entitled 'The Forest and Rangeland Renewable Resources Planning Act of 1974,' which directs and authorizes the USDA/FS to periodically prepare a Renewable Resource Assessment and long-range Renewable Resource Program. The continued effort is an extention of the current FAP programs with added emphasis on the development of techniques and methods to eventually provide a capability to acquire range and forest inventory information required by the Forest Service for the implementation of the Resources Planning Act. Presently FAP is documenting the results of a Soils Resource Inventory. These results (procedures and report) will be evaluated by the USFS to determine their applicability to present USFS soil inventory operations. The new technology will be transferred to the USFS by means of reports, procedures, and workshops. As a result of the FAP, TRICPS (Tri-County Investigation), a Nine Ecosystem Forest and Range Resource Inventory is underway. The project is designed to test remote sensing inventory techniques using Landsat and automatic data processing in 9 different forest and range ecosystems in the United States (See T-8 Nationwide Forest Resources Test Project).

**W77-70504** **177-51-85**
Lyndon B. Johnson Space Center, Houston, Tex.
**AGRICULTURAL CROP INVENTORY ADVANCED TECHNIQUES DEVELOPMENT**
A. L. Grandfield 713-483-2071
(177-51-85)

This RTOP covers research related to advanced technology development for LACIE and LACIE follow-on systems and it also considers plans for evaluating LACIE components. Advanced technology development is a group of research studies for (1) determining a preliminary design of a multicrop inventory system. (2) developing a model for heat transfer from wheat and other crop canopies and (3) for evaluating efficient ways to display ancillary data (non Landsat data) for an image interpreter. LACIE system evaluation is concerned with developing a LACIE/ERIP compatible computer system for testing candidate improvements to LACIE or LACIE follow-on systems. LACIE evaluation is also concerned with supporting the use of the LACIE error models for accuracy assessment studies in phase 2 and 3 of the LACIE.

**W77-70505** **177-52-41**
Goddard Space Flight Center, Greenbelt, Md.
**LAND USE/DEMOGRAPHIC RESEARCH**
J. W. Christenson 301-982-4978
(177-01-41)

The objective is to develop and evaluate techniques for application of remote sensing capabilities to the detection and monitoring of urbanized area land cover parameters in the Bureau of the Census population study activities. Specific objectives directly supporting this work are as follows: (1) extend current land cover signature development efforts to additional selected urbanized areas, (2) develop and evaluate techniques for incorporating census tract boundaries in interactive processing, (3) investigate effects of Landsat digital data reformatting and scene registration schemes on the change of radiometric fidelity of such data, and classification accuracy, (4) study future applications of Landsat-D type data and other forms of remotely sensed data (thermal, microwave, etc) for urbanized area analysis, and (5) preparation and support of Census/Urban Area ASVT. Remotely sensed data from Landsat will be analyzed using various information extraction systems, and the results will be evaluated with ground truth information. Several urbanized areas exhibiting different characteristics of landscape and demographic features will be selected as study areas. Thematic maps and information in tabular form, generated as a result of digital processing will be compiled in a framework of Bureau of the Census related statistical area subdivisions (census tracts, block parcels). All processing and evaluation will be done with close cooperation of the Bureau of the Census personnel. Document capability of recently developed image processing techniques for analysis of urbanized areas is the expected result.

**W77-70506** **177-52-42**
Goddard Space Flight Center, Greenbelt, Md.
**INFORMATION TRANSFER LABORATORY (INTRALAB)**
P. J. Cressy 301-982-2658
(177-52-42; 177-01-41)

The objectives are to demonstrate and evaluate the application of remotely-sensed data to user-identified information needs, in order to develop the operational use of Landsat and other remotely-sensed data. Intralab initiates and executes joint projects involving key users and/or key applications of remote sensing technology. Users participate with Intralab in short duration tasks (typically 3 - 6 month technical phase) focussed on user-identified issues and emphasizing techniques commensurate with user resources. Users supply ground truth and technical personnel to participate in the project. Intralab provides remotely-sensed data, contemporary analysis facilities, and discipline and support personnel. Intralab projects will: (1) demonstrate the application of remotely-sensed data to operational information needs, (2) identify processes by which users can incorporate such data into operational programs, and (3) establish user-identified benefits/requirements data for ERS mission planning.

**W77-70507** **177-52-83**
Slidell Computer Complex, Slidell, La.
**REMOTE SENSING TECHNIQUE AND APPLICATION DEVELOPMENT - EARTH RESOURCES LABORATORY**
D. W. Mooneyhan 504-255-3311
(177-32-83; 177-52-84)

The basic mission objectives of the Earth Resources Laboratory are as follows: (1) to conduct research investigations in the Mississippi/Louisiana/Gulf areas in the application of remote sensing, stressing the interest and needs of agencies in the area, (2) to extend these research investigations into experimental demonstration projects in cooperation with local agencies where appropriate, (3) to utilize existing aircraft and satellite programs as a primary source of remote sensing data and collect and analyze surface data for correlation with these flight data,

and (4) to conduct continuing studies of user requirements of potential applications in order to guide future research efforts. Experimental work is being conducted in a wide range of technique and application development projects in disciplinary areas that contribute to solution of representative resource inventory and management problems associated with land, wetlands, and coastal waters.

**W77-70508** **177-53-15**
Ames Research Center, Moffett Field, Calif.
**REMOTE SENSING OF SOIL MOISTURE AND CROP MOISTURE STRESS BY VISIBLE AND THERMAL INFRARED TECHNIQUES**
D. R. Chapman 415-965-5065
(177-53-13)

The objective of this effort is to evaluate the feasibility of measuring soil moisture and crop moisture stress by utilizing remotely sensed visible and infrared radiation. Prime emphasis is on the infrared-thermal inertia technique, wherein the diurnal variation of soil temperature is related to soil moisture content, and on a thermal infrared technique of measuring crop canopy temperature, wharein the difference in crop canopy and local air temperatures is indicative of water stress. This effort is aimed at developing techniques suitable for use with the Heat Capacity Mapping Mission Spacecraft. To accomplish this objective, Ames Research Center is working with the water Conservation Laboratory, U. S. Department of Agriculture, Phoenix, Arizona, with the University of Califorina at Davis, and with San Jose State University. Ames will be flying an infrared line scanner and a rapid scanning spectrometer, operating in the visible portion of the spectrum, over test areas provided by the Water Conservation Laboratoty and U.C. Davis. The Water Conservation Laboratory and U.C. Davis will be providing ground truth measurements. The data will be jointly analyzed. To guide the understanding of the problem, and to provide a means of estimating sources of measurement error, a computer model of soil moisture and temperature, including meteorological variables is being generated by San Jose State University. This model will be validated with experimental data, and ultimately used to correct remotely sensed data to yield more accurate values of soil moisture and crop stress.

**W77-70509** **177-53-41**
Goddard Space Flight Center, Greenbelt, Md.
**GEOLOGICAL INVESTIGATIONS USING SATELLITE AND RELATED DATA**
H. A. Tiedemann 301-982-5123

The objectives are to evaluate application of satellite data to geologic problems in mineral, fossil fuel and geothermal energy exploration, and nuclear plant siting; to increase computer and optical processing capabilities to extract data relevant to solution of these problems; and to develop criteria for new sensors with increased geologic capabilities. The approach will continue to develop (1) use of color/tonal anomalies as guides to surface alteration effects related to minerals, petroleum and geothermal sources, (2) ADP methods of linears mapping as a guide to subsurface structure and regional tectonic assessment, (3) expand computer and optical capabilities to improve analysis of digital data and imagery, and (4) study effect of spatial/spectral resolution changes on lithologic and structural mapping. The expected results are: (1) assessment of the capability of GSFC enhancement and extraction techniques to resolve energy- and environment-related geologic problems; and (2) identify limitations of present data and/or systems, to provide criteria for design of new sensor systems having increased geologic capabilities.

**W77-70510** **177-54-11**
Ames Research Center, Moffett Field, Calif.
**REMOTE SENSING FOR SNOW AND ICE MAPPING AND MONITORING**
D. R. Chapman 415-965-5065

The objectives of this RTOP are to determine snowpack properties by measurements of remote sensor technology for hydrological cycle data input, to achieve better utilization of water resources and hydroelectric energy production, and for flood forecasting. The objectives have been enlarged to include measurements of soil moisture, utilizing microwave techniques. The approach is to develop remote sensing techniques for measurement of extent, depth, density, and percent wetness of snowpacks. Surface systems are needed for ground-truth data, and also to provide information in DCP installations for watershed status on a time-progressive basis. The time of water runoff from snowpacks will be determined by measurement of wetness of snowpacks and underlying earth, using microwave attentuation between source and receivers. Airborne systems will be investigated using passive and active electromagnetic measurements. Satellite-based systems will include passive microwave measuremens to give synoptic, time-progressive surveys of snow coverage, water equivalent, and snowpack moisture. Imaging radar in satellites is being considered, for which back scattermeasurements are in progress to determine the feasibility of this approach.

**W77-70511** **177-54-22**
Goddard Space Flight Center, Greenbelt, Md.
**SEA ICE MONITORING**
P. Gloersen 301-982-6362
(177-54-22)

The objective of this program is to provide the important additional capability of routine observations of sea ice motion for the existing satellite quasioperational sea ice monitoring system for the purpose of providing increased safety for shipping operations in the arctic sea lanes and for arctic off-shore resource extraction, e.g., drilling platforms for off-shore oil. Efforts will be directed towards a cooperative research program with user agencies in conjunctions with the recently initiated Outer Continential Shelf program (OCS). The cooperative research program will entail both the acquisition of data, its interpretation, and a cooperative planning of a satellite operational ice warning system which will expand beyond the capability of the present quasi-operational sea ice monitoring system (with USN/FWF) to include ice dynamics. NASA aircraft will be used on an occasional basis for the evaluation of new sensor technology to be applied to sea ice monitoring on an operational basis. This RTOP supports the following major programs: (1) the multi-million dollar national Outer Continental Shelf (OCS) program, (2) the Nimbus G project, and (3) the Seasat A Project. More complete application of satellite microwave data from existing and scheduled satellites to provide sea ice information to maritime and resource development interests for purposes of safety and ecology is the expected result.

**W77-70512** **177-54-22**
Lewis Research Center, Cleveland, Ohio.
**REMOTE SENSING OF ICE AND VESSELS FOR SHIPPING APPLICATIONS**
H. Mark 216-433-4000

The objective is to develop remote sensing techniques for shipping applications in the Great Lakes, and North Atlantic, the Coastan Areas of the United States and the Arctic. The techniques developed shall be for the remote monitoring of sea ice in the Arctic, fresh water ice in the Great Lakes, icebergs in the North Atlantic and fishing vessels in the coastal areas of the United States. The operational requirements of the potential users are to be satisfied by the techniques so that they can result in transferable systems. All development efforts will utilize and/or extend the techniques and capabilities that have so far been developed for the Great Lakes Ice Information System (Project Icewarn). Although the development can be done effectively using aircraft, the techniques, if possible are to be designed to use data from existing and planned satellite systems.

**W77-70513** **177-54-41**
Goddard Space Flight Center, Greenbelt, Md.
**MONITORING AND MODELING OF HYDROLOGIC SYSTEMS**
A. Rango 301-982-5480

The objectives are: (1) to determine the capabilities of microwave sensors for measuring significant snowpack parameters and conclude digital snow analysis; (2) to determine the optimum sensor parameters for developing spaceborne microwave systems for snow measurements; (3) to investigate the application of remote sensing to new hydrologic modeling approaches and

conclude in-house model modification; and (4) to define potential ASVT for floodplain delineation. The approach will be as follows: (1) the microwave of the snowpack will be related to hydrological properties via A/C overflights and field experiments; (2) the ground-based measurements of scattering properties of snow will be continued and the frequency range extended plus emission measurements with GSFC multifrequency radiometers will be made; (3) new modeling techniques such as partial area hydrology and finite element modeling will be tested in combination with remote sensing data; and (4) digital floodplain mapping information systems will be tested in specific areas in cooperation with operational agencies. The expected results are: (1) 1976 A/C and field microwave measurements will be correlated with snowpack parameters, 1977 A/C - field studies will be conducted, and Landsat data suitability for operational digital snow mapping will be demonstrated; (2) a mobile field microwave facility will be developed and field data acquired; (3) in-house hydrologic models will accept remote sensing inputs, and remote sensing capability with partial area models and snowmelt runoff subroutines will be demonstrated; and (4) a floodplain ASVT preliminary project plan will be completed.

**W77-70514** **177-54-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**WETLANDS MAPPING USING REMOTELY SENSED DATA**
D. P. Burcham 213-354-3028

The objective of the project is to develop techniques for using LANDSAT digital data to identify, classify, and map major wetland types identified by the Fish and Wildlife Service (FWS) as being of importance to a national inventory of wetlands. The analyzed data will be correlated with baseline data being collected in the FWS inventory to evaluate the accuracy and potential for use of these techniques for future wetland inventories, wetland change detection, and other types of wetland studies. The following will be the methods of approach: (1) Identify and separate wetlands from other land cover and land uses. Different techniques will be developed and employed as required for the isolation of different types of wetlands. (2) Develop techniques to classify and map wetlands using LANDSAT and other digital data; such maps will provide a data base for multispectral updating and monitoring. Classification will be based on the 'Interim Classification of Wetlands and Aquatic Habitats of the United States' (FWS, in progress), Circular 671, revised (Anderson, et al., 1975), and other systems as necessary. The problems of seasonal fluctuation of hydrologic boundaries as it affects mapping and defines wetland 'habitat types' will be considered in technique development. (3) Develop presentation techniques for wetland information in formats of value to FWS and a wide variety of other users. (4) Train user agencies in the use and analysis of LANDSAT digital data as it relates to wetlands. Primary emphasis will be on digital image processing in the JPL Image Processing Laboratory. The VICAR system available there has programs for registration, multispectral analysis, seasonal and temporal analysis, image ratioing, and other enhancement techniques, the MILUS/IBIS geocoding and land use mapping techniques, and many others. These will be used as appropriate, and new programs will be developed if necessary.

**W77-70515** **177-54-80**
Lyndon B. Johnson Space Center, Houston, Tex.
**APPLICATION OF REMOTE SENSOR INPUTS TO MODELING SMALL WATERSHEDS**
A. W. Patteson 713-483-4506

There are two end member approaches for the prediction of runoff from a watershed, stochastic and deterministic. The stochastic method depends upon examination of the records of past runoff from a watershed and then using this data to statistically extrapolate what future runoff will be. The deterministic method breaks down the runoff process into its individual component parts and studies the effect each part has on the runoff. To date no completely deterministic model has been successful. In between the stochastic and deterministic model is the parametric model. There are two approaches to parametric modeling. One approach is to divide the runoff parameters into as many groups as possible and still have a manageable model. The other is to lump as many of the runoff measuring parameters as possible into a few parameters and to empirically derive constants that evaluate these few parameters. This latter approach has been used to develop a small watershed model that applies passive microwave data directly to the runoff prediction. The factors that influence microwave brightness temperatures (surface roughness, vegetation, near surface soil moisture, soil type) are also the factors that influence runoff. Using data collected in a limited geographic area a model relating microwave brightness temperature to runoff was developed. Work is now in progress to extend this model to a larger area.

**W77-70516** **177-55-31**
Langley Research Center, Langley Station, Va.
**COASTAL PROCESSES (WATER COLOR)**
P. F. Holloway 804-827-2893

The objectives are: (1) to develop improved techniques for separating and quantifying various sediment concentrations from remote sensing measurements, and (2) to determine the spectral bands which provide the characteristic signatures that relate remote sensor measurements to aquatic primary productivity. Development of a coastal sediments laboratory for measurement of upwelled spectral signatures under controlled conditions will be completed. The upwelled signatures and in-water optical data will be used to test and validate existing optical models. Actual sediments from local waters will be tested in the laboratory and results compared with aircraft remotely sensed data. Thin layer and high pressure liquid chromatography will be used to obtain in vitro absorption spectra of key carotenoid pigments known to exist in planktonic algae. These spectra will be correlated to existing in vivo fluorescent and absorption spectra to establish carotenoid recognition schemes for remote sensing application.

**W77-70517** **177-55-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GEOSAR STUDY**
D. P. Burcham 213-354-3028

The objective of this RTOP is to conduct a mission and system study for orbiting geology synthetic aperture radar (GEOSAR) and to evaluate the potential use of such a remote sensor in the field of geology in general, and mineral and petroleum exploration in particular. The approach is to conduct a number of application verification experiments using the present aircraft system to evaluate the capabilities of the imaging radar in providing information which can be used in mineral exploration, petroleum exploration, gravel resources mapping, structural geology and other geologic applications. These experiments would also allow the evaluation of the optimum radar system parameters such as look angle, frequency,polarization, dynamic range, stereo look which would be used in the radar system and mission study. The application verification experiments will be conducted with active participation of user agencies and scientists. The study is divided into three major areas: (1) mission study, (2) radar system study, and (3) verification experiments. A study manager/scientist will coordinate and direct the overall effort. The AUWG which is being established by NASA will play a key role in advising and evaluating the effort of the study and the application verification experiments.

**W77-70518** **177-55-61**
Wallops Station, Wallops Island, Va.
**ELUCIDATION OF UNDERWATER RADIATIVE TRANSFER PROCESS FOR THE INTERPRETATION OF OCEAN COLOR REMOTE SENSING**
H. H. Kim 804-824-3411
(506-18-15)

The objective of this project is to ascertain and describe the optical processes which take place in water and are responsible for ocean color. A two year plan is proposed to accomplish the above objective. The study will include both hydrospheric optical data gathering and a modelling of the optical process based on a statistical analysis of the empirical data. There are three interconnected phases in this plan: (1) absolute intensity measurement of down and upwelling solar radiation from the Atlantic Ocean, (2) scattering phase function measurement, and (3) modelling of underwater optical process.

**W77-70519** **177-61-42**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**MULTIPLE INPUT LAND USE ANALYSES FOR METROPOLITAN/REGIONAL AREA APPLICATIONS**
D. P. Burcham 213-354-3028
(141-95-01)

The long term objectives of this land use program are to (1) integrate digital imagery with digital information systems, (2) develop procedures to register the number of geocoded variables available to the user, and (3) serve metropolitan regional planning needs. During the FY-76 period, the level of funding received has permitted pursuit of the following activities: (1) definition of the requirements for a Multiple Input Land Use System (MILUS), (2) development of the software (under RTOP 656-11-03-03) for generating tabular data sets from thematically classified digital images on both synthetic and actual cases, (3) development of a more flexible and up-to-date image registration system (in conjunction with Viking and Mariner Jupiter Saturn mission requirements), (4) generation of land use data and land use change statistics using MILUS and registration of imagery of different data for several agencies (HUD, Census, L.A. City), (5) Thematic Mapper simulation for urban applications, (6) expansion of LUMIS Advisory Committee contacts and introduction of MILUS capabilities to reassess user needs under the expanded technological capabilities. During FY-77, given that funds are provided at the level indicated, the ASVT definition phase for the Urban Information Systems for the southern California region should be completed. By the end of FY-77 software development and construction of a demonstration geocoded information system of land use for metropolitan Los Angeles should be complete, as should prototype studies of urban change detection for the U.S. Census and Department of Housing and Urban Development. Transfer to an ASVT phase should occur in FY-78.

**W77-70520** **177-64-11**
Ames Research Center, Moffett Field, Calif.
**WATER MANAGEMENT AND CONTROL PRE-ASVT**
D. R. Chapman 415-965-5065
(177-72-11)

The objective of this RTOP is to make substantial verification of water demand prediction techniques (developed in NASA in general and under NASA Grant NGL 05-003-404 to the University of California in particular) so that a decision can be made concerning the initiation and scope of a water management ASVT involving the California Department of Water Resources (DWR). The approach will be to work directly with the DWR so that the analytical expertise within the University system can be applied to the specific problem areas and geographical locations of primary interest to the DWR. Remote sensing technology and various levels of human participation and automation will be evaluated for accuracy, timeliness, cost, ease of implementation, and overall value in the DWR data collection and water demand analysis system. The possibility of an ASVT (with preliminary cost-effectiveness and analysis and scope evaluation) will be studied, and preliminary project plan prepared if appropriate.

**W77-70521** **177-65-11**
Ames Research Center, Moffett Field, Calif.
**ASVT DEFINITION - REMOTE SENSING APPLICATIONS TO COASTAL ZONE MANAGEMENT IN HAWAII**
D. R. Chapman 415-965-5065

The objectives of this ASVT definition project are to define the necessary tasks required to successfully conduct an ASVT with the State of Hawaii and to develop a detailed project plan for conducting the ASVT. The general objective of the ASVT itself will be: (1) to develop the necessary methodologies and to devise a system for utilizing remotely sensed data that will be useful to the user/decision maker in administering statewide Coastal Zone Management; and (2) to demonstrate that such a system will lead to more effective and cost-beneficial program administration. The approach in this phase will be to formalize project task teams within NASA and the State of Hawaii to conduct preliminary analysis and write a detailed project plan. The plan will formulate a system for analyzing, manipulating and displaying remotely sensed data in a format usable by the user/decision maker. Coastal Zone Management applications will be emphasized. Applicable techniques already developed in other programs will be fully utilized.

**W77-70522** **177-66-11**
Ames Research Center, Moffett Field, Calif.
**DEFINITION OF AN ASVT FOR TROPHIC CLASSIFICATION OF LAKES FOR PUBLIC LAW 92-500 PURPOSES**
D. R. Chapman 415-965-5065
(176-30-51)

The objectives of this work are (1) to determine if current technology is sufficient to proceed with an ASVT for the classification of lakes according to their trophic status for the purpose of permitting user agencies to comply with Public Law 92-500 so that they may obtain funding for lake projects and (2) to develop a Preliminary Project Plan in concert with user agencies for such an ASVT should it appear feasible. The approach will be a joint investigation with JPL to examine (1) currently defined problems in the use of the LANDSAT sensor (sensitivity, signal-to-noise ratio, spectral resolution and spectral coverage) for measuring low reflectance objects like lakes, (2) the effect of atmospheric variations on the repeatability of LANDSAT lake classification and (3) the effects of lake dynamics on classification schemes. Both the approving agency, the EPA, and the user agencies in the states will work with Ames and JPL in developing the Preliminary Project Plan.

**W77-70523** **177-70-21**
Lewis Research Center, Cleveland, Ohio.
**REGIONAL APPLICATIONS TRANSFER**
H. Mark 216-433-4000
(177-54-22; 176-30-21)

The objective and approach are to develop regional applications of remote sensing which will ultimately require the operational use of satellite data. Specifically, regional resource and other applications problems identified by nearby states (e.g., Ohio, Kentucky, Pennsylvania) and other problems of interest to Federal agencies in this region (e.g., DOI, DOT, and COE) will be addressed. Significant effort on the part of the cooperating agency must be forthcoming for the program to qualify.

**W77-70524** **177-72-11**
Ames Research Center, Moffett Field, Calif.
**INTEGRATED EARTH RESOURCE SURVEY AND LAND USE INVENTORY IN CALIFORNIA**
D. R. Chapman 415-965-5065
(177-64-11)

The objective of this RTOP is to provide the mechanism for focusing Center competence, university research capability, and industry know-how on California state and local agency problems in natural resource and land-use inventory and management. The approach will be to coordinate user agency needs within the state with appropriate NASA technology, university analytical capability, and industry support to bring about the most fruitful applications of remote sensing, data collection, and data processing. Research efforts such as currently being carried out by the University of California under Grant NGL 05-003-404 will be carefully directed toward state and local problems in water management, agricultural crop productivity, pollution, land use and urbanization, forest resources, etc. NASA involvement may vary in extent from the provisions of needed data for user agencies to a complete evaluation of a project for potential ASVT status.

## Space Processing

**W77-70525** **179-30-23**
Langley Research Center, Langley Station, Va.
**MOLECULAR SHIELD FACILITY**
P. F. Holloway 804-827-2893
(645-50-10)

The space shuttle planned by NASA offers opportunities for materials research and technology advances not possible in

terrestrial laboratories. This research requires a zero gravity - low pressure environment, but the low pressure (less than 10 to the minus 12th power torr) required to eliminate contamination effects is not attainable at presently planned orbital altitudes (P sub atm greater than 10 to the minus 7th power torr). However, by use of the attitude control capability and the orbital speed of the shuttle, it has been shown that an extremely low pressure (less than 10 to the minus 13th power torr) can be obtained within a properly designed structure (Molecular Shield Facility) which has sufficient volume to accommodate these materials research experiments. The objective of this effort is to perform necessary research to establish baseline configuration requirements for a Molecular Shield Vacuum Facility to accommodate a wide range of materials processing experiments. It is planned to perform preliminary technical and economic studies for potential low density experiments such as evaporation and vacuum distillation purification of materials, research on clean surfaces, and thin film vapor deposition of semiconductors.

## Technical Consultant and Support Studies

**W77-70526** **643-10-01**
Lewis Research Center, Cleveland, Ohio.
**TECHNICAL CONSULTATION SERVICES**
Joseph N. Sivo 216-433-4000

The objectives are to provide technical consultation services support in the area of high powered broadcast satellite technology in preparation for the 1977 and 1979 WARCs, and conduct studies, technical assessments, and where necessary, measurements in the area of high powered broadcast satellite technology, culminating in technical papers required for CCIR SG's on frequency utilization and broadcasting (sound/television). Following an assessment of the more important issues to be considered in the 1979 WARC, combined in-house and contracted studies will be performed to establish trade-off coefficients relating the parameters of interest such as radiated power, flux density, frequency utilization, orbit sharing, side lobe control, interference, etc.

## Advanced Communications Research

**W77-70527** **650-20-01**
Lewis Research Center, Cleveland, Ohio.
**COMMUNICATIONS TECHNOLOGY PLANNING**
Joseph N. Sivo 216-433-4000

This is a continuing effort with the objectives of identifying advanced technology users, their needs, and potentially cost-effective technology innovations which would meet these needs; assessing and stimulating advanced techniques with potential application to these needs; providing program plans for and demonstration of selected technology items and techniques; and developing joint NASA/industry programs for implementing the technology and techniques. Key elements of the program are: (1) interaction with other government agencies, industry, and the ultimate consumers of communication services to establish and understand their needs and requirements, (2) continual assessment and stimulation of advanced communication techniques aimed at new and/or improved services with application to user needs, and (3) potential technology innovations will be identified and total system concepts which employ these innovations and meet users' needs and requirements will be synthesized and evaluated using cost benefit analysis.

**W77-70528** **650-60-14**
Lewis Research Center, Cleveland, Ohio.
**HIGH POWER TRANSMITTER TECHNOLOGY**
R. E. Alexovich 216-433-4000
(506-20-23; 643-10-01; 650-40-10)

The objective is to provide increased knowledge and capability for high power space transmitter systems to meet general satellite communications needs of the future. The approach is to achieve this objective. Studies and investigations of space-Earth propagation and high power rf component and systems technology will be conducted for space communications applications in new high frequency bands of 40 and 80 GHz and bands above 90 GHz.

## Data Management

**W77-70529** **656-61-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SPACECRAFT ON-BOARD RADAR IMAGE PROCESSOR**
R. V. Powell 213-354-6586
(506-20-11; 506-20-22; 656-61-02)

Currently available technology cannot satisfy the synthetic aperture radar (SAR) processing requirements of future Seasat missions. A very promising solution is to develop an on-board SAR processor. The most cost-effective approach to this goal is to develop a ground-based test-bed SAR processor based on information derived from SAR processing research and development tasks which have been performed at JPL. A hybird CCD/digital test-bed processor will be developed to demonstrate the feasibility of ultimately developing an on-board SAR processor for space applications. The test-bed processor will also provide an important tool for an anticipated follow-on effort to develop a flight prototype SAR processor. The work schedule of this RTOP is such that Seasat A data can be used to aid in the initial evaluation and demonstration efforts. The opportunity to interact with Seasat A SAR data users will provide valuable feedback regarding the processor's usefulness. Development of the processor will be accomplished through a combination of in-house and contract work. The design, construction, and initial evaluation of the test-bed processor will be completed by the end of FY-78.

**W77-70530** **656-62-02**
Langley Research Center, Langley Station, Va.
**SYSTEMS ENGINEERING ANALYSIS AND DATA/INFORMATION TECHNOLOGY FOR POLLUTION MONITORING**
P. F. Holloway 804-827-2893
(656-62-01)

The objectives of this RTOP are: (1) to determine user technology needs relative to data/information products required to perform pollution monitoring activities, (2) to provide an assessment of current NASA sensing and data handling technology to provide validated data products to meet these needs, (3) to provide optimized concepts which will lead to the most acceptable data system from both the users' and systems engineers' viewpoint, (4) to identify pacing technology developments required to provide the data systems, and (5) to document the results of this effort for future planning and action by OA, OAST, and other interested organizations.

# OFFICE OF SPACE SCIENCES

## Solar Terrestrial

**W77-70531** **170-36-55**
Goddard Space Flight Center, Greenbelt, Md.
**PLASMAS PARTICIPLES AND PARTICLES FIELD INTERACTION**
Keith W. Ogilvie 301-982-5904

The object of this research is to increase the knowledge and understanding of non-thermal plasmas occurring in the interplanetary medium and the magnetosphere, and also to improve the theoretical description of their properties. This requires continuous improvement in measurement techniques, and interpretation of the results of appropriate space experiments. The interpretation requires corresponding improvements in numerical techniques, and in methods of data display.

**W77-70532** 170-36-55
Marshall Space Flight Center, Huntsville, Ala.
**INSTRUMENT DEVELOPMENT**
Charles R. Chappell 205-453-3036

The development of space plasma instrumentation for automated spacecraft and sounding rocket payloads is the objective of continued joint activities with the Lockheed Palo Alto Research Laboratory. Projects include (1) a study of grind configurations for the low energy ion spectrometer for the NASA ISEE mission, (2) the electronics box for a multi-headed light ion mass spectrometer on the DOD SCATHA spacecraft, (3) in-house design, development and fabrication of three analyzer heads for the light ion mass spectrometer to be flown on the DOD SCATHA satellite, and (4) completion of in-house design and fabrication of a dual retarding potential analyzer for the E//B sounding rocket. Dr. Chappell is a Co-Investigator for the NASA ISEE mission and Principal Investigator for the DOD SCATHA project.

**W77-70533** 170-36-55
Ames Research Center, Moffett Field, Calif.
**MAGNETOSPHERIC PHYSICS - PARTICLES AND PARTICLE/FIELD INTERACTION**
D. R. Chapman 415-965-5065
(385-36-01)

The objective is to extend understanding of the dynamics, origin and termination of the solar wind by observations and their theoretical interpretation, and to investigate methods for improving space plasma observations. Techniques to improve the lifetime, reliability, sensitivity, sampling rate, dynamic range and resolution of space plasma experiments are studied. Ways to refine measurement resolutions for the individual plasma parameters, the temperature density, velocity vector and temperature anisotropy, and investigation of techniques for improvement of calibration procedures and calibration data analysis are included. Theoretical studies provide designs of plasma analyzers for testing in the laboratory. Theoretical studies aimed at understanding the large-scale dynamics of the solar wind, its acceleration and heating mechanisms and its properties at large heliocentric distances are carried out. These studies employ known theoretical techniques of plasma physics and magnetohydrodynamics, and also often require extensions of basic theoretical plasma physics. Theoretical developments are related to spacecraft plasma and magnetic data, as well as to indirect observations of the solar wind.

**W77-70534** 170-36-56
Ames Research Center, Moffett Field, Calif.
**PARTICLES AND PARTICLE PHOTON INTERACTIONS (AERONOMY)**
D. R. Chapman 415-965-5065
(185-47-67; 385-36-01)

The objective is to investigate the physics of the earth's topside ionosphere and plasmasphere and the coupling of these regions with the magnetosphere and solar wind. Theoretical studies of the thermal-charged particle composition, density and temperature are being performed by means of numerical solutions of continuity, momentum, and energy balance equations. Data from the Alouette, ISIS, and other satellites will be used to establish boundary conditions and to assess the significance of various physical processes such as electron and ion drift and diffusive transport. The theory and techniques involved are applicable to the study of atmospheres and ionospheres of other planets and planetary satellites and their effects on radio communications of space probes. In fact, the basic techniques being applied were developed for studying the ionospheres of Mars, Venus, Titan, and Io.

**W77-70535** 170-36-56
Goddard Space Flight Center, Greenbelt, Md.
**MAGNETOSPHERIC PHYSICS: PARTICLES AND PARTICLEPHOTON INTERACTIONS**
James P. Heppner 301-982-4797

The objectives are: (1) to conceive, design, develop and test new techniques for space measurements of electric fields, auroral particles, trapped particles, solar-interplanetary particles, plasma waves, wave-particle interactions, photon-particle interactions, plasma composition, ionospheric winds, electron density and atomic and molecular collision processes with particular emphasis on magnetospheric and ionospheric regions, and (2) to analyze problems and conduct theoretical studies in magnetodynamics, plasma physics, and atomic and molecular interactions. The approach includes detector and supporting electronics, design, laboratory and contractor fabrication and testing, and theoretical studies of field and particle phenomena and distributions in space. This effort is expected to produce: (1) instrumentation having the capability to make measurements that previously have not been possible, particularly in areas where there are significant gaps in our knowledge as a consequence of there being few or no measurements, (2) accurate models of fields in space which have both scientific and technological utility, (3) indices which describe the instantaneous degree of disturbance in the ionosphere and magnetosphere, (4) advances in the understanding of plasma instabilities, and (5) new techniques for studying the transport of ion and neutral particles in the ionosphere.

**W77-70536** 170-38-51
Goddard Space Flight Center, Greenbelt, Md.
**DEVELOPMENT OF SOLAR SPACELAB EXPERIMENT AND HARDWARE**
J. C. Brandt 301-982-4701

The objective of this RTOP is to develop payloads which contribute toward the solution of well-defined solar research problems. These payload activities will proceed with the ultimate objective of flying on the shuttle's Spacelab. In such problem-oriented Spacelab missions, a payload of instruments is assembled which, by simultaneous observations of a phenomenon, such as a solar flare or the outflow of the solar wind at the base of the corona, provides in complete detail the physical data needed for a cogent model of the phenomenon. An example of such a mission is SMM for solar flare research. This spacecraft will be retrieved by the shuttle and flown again with refurbished instrumentation. Additional research problems will provide the bases for a series of missions using the shuttle. One of these will be a study of coronal structures contributing to the solar wind and the interplanetary plasma. A second will be a study of the sources of high energy particles on the sun, emphasizing instrumentation that could not be accommodated and may be supplementary to the SMM instruments. Missions emphasizing the phenomenon of coronal heating and mass and energy balance in the chromosphere are also contemplated. In each case a number of different instruments covering a wide range of wavelengths is required. They will be selected on the basis of making comprehensive measurements in their specific wavelength regions in a format which is coordinated with and complimentary to the other instruments in the payload. For example, all instruments will operate with the same temporal and spatial resolution to the maximum possible extent. The instruments considered for these payloads are: (1) a solar visible and ultraviolet telescope (Helioscope) with aperture greater than or equal to 65 cm. Current planning contemplates a 1.25 m primary Gregorian telescope and (2) a high resolution 1000-2850A spectrometer used at the focus of the telescope and observing line profiles from the chromosphere and the transition region

**W77-70537** 170-38-52
Goddard Space Flight Center, Greenbelt, Md.
**GROUND BASED OBSERVATIONS OF THE SUN**
Robert W. Hobbs 301-982-2591

The major objective is the measurement of solar radiation at those wavelengths accessible from the ground (primarily 3000 to 11000A) with resolution (spatial, spectral, temporal, velocity) suitable for supporting investigations of solar phenomena (flares, active regions, wave motion) carried out in the EUV, X-rays, and gamma rays by Orbiting Solar Observatories, SMM and other flight missions in the NASA Solar Physics Program, and for basic research on the sun. Other objectives are (1) the observation and spectral analysis of high temperature laboratory plasmas in order to interpret solar spectra in the range 10 to 800A for the purpose of understanding physical processes in the solar corona, (2) the laboratory observation of the spectra

of important constituents of the terrestrial atmosphere in support of observations of these constituents by OSO-8 and SMM using the sun as a light source, (3) the design, testing and construction of a device involving a non-degradable filter which will allow accurate measurement of any variability (to 1%) in the solar UV flux from 2000 to 4500A over several years, and (4) the analysis of comet-tail photographs to determine the velocity field of the solar wind. Two observatory facilities and several laboratory programs are maintained for this purpose. The dedicated vacuum solar telescope and multichannel spectrometer now operated by the Laboratory for Solar Physics and Astrophysics at the Sacramento Peak Observatory are used to obtain photometric data, spectrohelingraphs and line profiles at many wavelengths simultaneously. The Zeiss filtergraph at the GSFC Optical Site is being modified to record and analyze solar chromospheric velocity fields.

**W77-70538** **170-38-53**
Goddard Space Flight Center, Greenbelt, Md.
**EXPERIMENT DEVELOPMENT - LABORATORY AND THEORETICAL SOLAR PHYSICS**
J. C. Brandt 301-982-4701

The general objective is to develop fundamental techniques which support the Laboratory's ongoing programs. These techniques ultimately are both experimental (applicable to the areas of design of flight instruments) and theoretical (analysis of returned data). However, at the initial level of investigation, fundamental physical processes must be investigated and defined before development of solar models based on these processes can be developed. Likewise, fundamental understanding of spectra observed on the sun is confirmed, if not originally suggested, by laboratory and theoretical work. Among such work is the identification of spectral lines in high energy spark discharges, the calculation of the transition probabilities of atomic transitions, and the development of techniques for the analysis of space-craft observations. Each of these areas is investigated in the context of ultimate application to instruments or theoretical modeling of the solar atmosphere carried out by members of the laboratory. A solar flare objective is to conduct theoretical research on the origin and radiations of energetic nuclei and electrons in solar flares. These particles produce observable gamma-ray lines, high-energy X-ray and gamma-ray continua, high-frequency radio emission, and charged particle fluxes in interplanetary space. Specific objectives include the evaluation of the properties of high-energy flare radiations; the comparison of these radiations with observations; and the determination of the particle acceleration mechanism or mechanisms in solar flares. The latter objective is to be achieved through both theoretical investigation of acceleration mechanisms and detailed study of the physical parameters of charged particle populations in flares derived from the observed photon and particle radiations.

## Launch Vehicle Development

**W77-70539** **180-72-50**
Langley Research Center, Langley Station, Va.
**ANALYSIS OF ENVIRONMENTAL IMPACT OF EXPENDABLE LAUNCH VEHICLE EFFLUENTS**
P. F. Holloway 804-827-2893

The objectives of this research are to examine the effluent from NASA unmanned launch operations which may alter the environment and to conduct a program to assess the possible impact of these operations on the environment. The type and amount of effluents from launch operations will be determined from studies of the launch systems. Analytical models are being developed and applied by the Marshall Space Flight Center to describe increases in concentration and dispersion of launch vehicle effluents. Measurements of the concentration and dispersion of effluents from selected launches will be made by the Langley Research Center. The analytical predictions and the experimental measurements will be used jointly to assess the effects of NASA umanned launch operations on the environment. The primary environmental effects which will be determined are: (a) the spatial and temporal distribution of toxic materials in the vicinity of the launch site resulting from NASA unmanned launch operations; (b) possible adverse effects of exhaust effluents on vegetation and man in the vicinity of the launch sites; (c) the type and amount of material deposited in the troposphere during launch operations; and (d) the ground level effects of precipitation scavenging of the hydrogen chloride from solid rocket tropospheric 'ground clouds'. This study is being coordinated with other related studies on the environmental impact of exhaust effluents.

## Planetary Exploration SR&T - Science

**W77-70540** **185-47-32**
Lyndon B. Johnson Space Center, Houston, Tex.
**SPECTROSCOPY OF PLANETARY ATMOSPHERES**
A. E. Potter 713-483-2576

The general objective is to determine the structure and composition of planetary atmospheres, with emphasis on the atmosphere relevant to planetary surface chemistry and geology. Much of this work will support experiment definition for the planning of planetary probe missions. Specific objectives are as follows: (1) The composition of the deeper layers of the Venus atmosphere, their physical state, and circulation patterns must be known to comprehend the surface chemistry and geology. In particular, we propose to to define the concentrations and circulation patterns of chemically active constituents of the Venus atmosphere (HCl, HF, H2O). (2) After many years of study the existence of an inhomogenous cloud layer is still unresolved, and there is no information available on circulation patterns in the atmosphere of Uranus. Using new instrumentation it should be possible to observe gross methane cloud structures and to provide some data on circulation patterns. (3) The escape flux of H from the earth's atmosphere is a fundamental problem, for which more data is required. The objective is to measure critical rate constants which are pertinent to this problem. The approach is as follows: (1) The global variation of abundances and temperatures of chemically active gases near the top of the Venus cloud layer can be determined from spatially resolved high-spectral-resolution infrared measurements using Michelson or Fabry-Perot interferometers at the 2.7 meter McDonald Observatory telescope. These global patterns can be used to constrain models of the Venus atmosphere below the clouds. These models may be then used to define the chemical composition of the lower atmosphere. (2) The structure and circulation of methane clouds on Uranus will be deduced from narrow-band imagery of Uranus obtained with image intensifer systems. The filters chosen will be centered on the methane and hydrogen absorption bands. (3) The merged beams apparatus will be completed, tested, and used to measure important ion-molecule reactions, specifically O(+) + H yields O + H(+). This reaction is known to be important in determining the temperature of the earth's upper atmosphere and the escape flux of hydrogen from the earth.

**W77-70541** **185-47-51**
Goddard Space Flight Center, Greenbelt, Md.
**ABSOLUTE PRESSURE MOLECULAR AND ATOMIC BEAM CALIBRATION TECHNIQUES FOR MASS SPECTROMETERS**
H. B. Niemann 301-982-4706

The objective of this work is to develop new laboratory techniques and to construct facilities for testing and calibration of instruments to measure the neutral particle composition and temperature of planetary atmospheres. The different atmospheric environments encountered in the various planetary and interplanetary missions as well as the different scientific goals set for the study of the planets require an extensive instrument and test facility development program which leads to a satisfactory laboratory capability for evaluation and calibration of flight instrument concepts and subsequently flight instruments. The different chemical properties of the various atmospheric constituents and the various gas dynamic conditions expected in a planetary entry or cometary encounter make it necessary to

develop several separate systems each with a limited range of flexibility which together satisfy the test requirements. Static pressure calibration systems have been developed for calibration of mass spectrometers with non-reactive gases in the pressure range suitable for mass spectrometer operation, i.e., less than or equal to 0.001 mb. This technique will be expanded to include pressure regions up to 100 bar, where instruments with extended dynamic ranges of more than or equal to 10 to the ninth power can be calibrated for detection of minor constituents and the precise determination of isotope ratios. High speed computer compatible data recording is planned to improve measurement accuracy and data handling efficiency.

**W77-70542** **185-47-52**
Goddard Space Flight Center, Greenbelt, Md.
**INSTRUMENT DEVELOPMENT FOR NEUTRAL GAS COMPOSITION AND DENSITY MEASUREMENTS IN PLANETARY ATMOSPHERES**
H. B. Niemann 301-982-4706

This research plan is concerned with the overall improvement of neutral gas composition measurements planned for the atmospheres of earth, the planets, and comets. In general, improvements are sought in two basic areas, (1) sensor concept and application, and (2) optimization of basic instrument parameters in anticipation of restrictive mission constraints. In the first area, sensor development will be directed toward (1) the improvement of ambient gas sampling techniques for high velocity probes into high density atmospheres (e.g., outer planets entry probes), (2) the design of more efficient ion sources of both the 'open' type which provides side-energy focussing, and the 'closed' type which increases the thermalization of the gas being measured, and (3) development of a neutral particle reparticle retarding potential analyzer for high velocity probes. In the second area, neutral mass spectrometer system development will be directed toward optimizing existing techniques in view of rigorous requirements anticipated in forthcoming planetary and cometary flight opportunities. This work will concentrate on (1) development of smaller, lighter, higher resolution, less expensive mass analyzers, (2) improvement of ion current detectors applicable to digital systems, emphasizing accuracy, sensitivity, and stability, and (3) development of improved digital logic and on-board data processing sub-systems.

**W77-70543** **185-47-54**
Goddard Space Flight Center, Greenbelt, Md.
**DEVELOPMENT OF MEASUREMENT TECHNIQUES FOR GAS AND CLOUD PARTICLE COMPOSITION IN HIGH PRESSURE ATMOSPHERES**
H. B. Niemann 301-982-4706

The objective of this work is to develop a practical technique for the determination of the composition of the gas and the cloud particles in the lower atmospheres of the planets. The method of mass spectrometry for the composition determination of solid materials and condensibles will be adopted for spaceflight application. Several different atmosphere sampling techniques will be developed and studied for optimum efficiency in the specific application of the various principle atmospheres. Sampling techniques employed in the high temperature CO2 environment in the lower atmosphere of Venus differ significantly from those employed in the relatively cool H2/He environment in the lower atmospheres of the outer planets. The analysis of solid particles deserves special attention as it requires a much higher degree of instrument complexity than required for atmospheric gas analysis. Laboratory proven techniques will be adopted for flight application when practical and new sampling concepts will be developed when required.

**W77-70544** **185-47-55**
Goddard Space Flight Center, Greenbelt, Md.
**SPECTROSCOPY AND PHOTOCHEMISTRY OF PLANETARY AND COMETARY MOLECULES**
L. J. Stief 301-982-2529

The objectives of this problem are to measure the optical and chemical properties of atoms, free radicals and molecules which are important in understanding the composition of planetary atmospheres and comets. Emphasis is placed on those problems which are of immediate concern for interpreting the results of rocket and satellite observations. In these investigations the well known techniques of optical spectroscopy, photochemistry and chemical kinetics are applied under well defined experimental conditions. The flash photolysis-resonance fluorescence apparatus is equipped with a variable temperature cell and the entire experiment is linked to the IBM/1800 computer for realtime data reduction and analysis. Time resolved detection of the atomic species is achieved via resonance fluorescence and/or resonance absorption. The apparatus is being used to measure relative probability of primary photodissociation channels and to measure absolute rate constants as a function of temperature for atom-molecule reactions. The addition of a tunable CW dye laser will extend the capabilities of the apparatus to include detection of free radical species. Two types of spectroscopic measurements are made. In one, photoabsorption and photoionization cross sections are measured. In fortuitous situations where broad band detectors can be utilized, cross sections are determined for producing photoionization and photodissociation fragments in excited electronic states. A unique double beam technique allows absorption cross sections to be determined with an absolute accuracy of 5%. All experimental parameters are read in realtime into an IBM 1800 computer greatly reducing the time for processing the data and improving the accuracy of the results. The second type of experiment determines electron impact excitation cross sections for emissions which lie between 500 and 2000 A. Using a double monochromator technique to calibrate the apparatus below 1000 A, cross sections were determined for N2, O2, and Ar in this spectral region for the first time.

**W77-70545** **185-47-56**
Goddard Space Flight Center, Greenbelt, Md.
**NEGATIVE IONS IN PLANETARY ATMOSPHERES**
A. C. Aikin 301-982-4913

The objective is to determine the altitude distribution and species of negative ion present in planetary atmospheres. Since negative ion formation and species will depend on the presence of minor neutral atmospheric constituents, identification of negative ions indicates the presence of trace constituents. The presence or absence of negative ions affects the propagation of radio signals through the planet's ionosphere. One of the objectives of this research is the development of a negative ion detection system for sampling planetary atmospheres. This system will initially be utilized for the Earth's atmosphere. The research has application to the manned and unmanned exploration of the Martian surface, since it defines the electrical environment in which systems operate. It has application to planetary meteorology in that negative ions act as tracers of minor neutral constituents whose distribution will be a function of photochemistry and general circulation.

**W77-70546** **185-47-57**
Goddard Space Flight Center, Greenbelt, Md.
**DYNAMICS OF PLANETARY ATMOSPHERES**
J. A. Pirraglia 301-982-4528

Recent planetary missions supplemented by ground based and airborne measurements have greatly increased our knowledge of the atmospheres of Jupiter, Venus and especially Mars, and future missions promise further results. For a better understanding of these atmospheres it is necessary to develop a general approach to theoretical atmospheric dynamics and composition based upon the existing temperature structure and compositional data obtained from planetary missions and from laboratory studies of the opacities and optical properties of the atmospheric constituents. The analytical techniques developed in conjunction with laboratory measurements will be used in the interpretation of existing data and in the improvement of models which are necessary to consolidate the measured quantities into a comprehensive view of the solar system. The planets and their satellites present contrasts in mass, rotation rates, radiative time constants, heat deposition and topographic influence of the atmosphere. In addition to the dynamical quantities the planets have atmospheric composition, aerosol and surface volatile differences which are intimately related to the dynamics. These widely differing conditions permit the isolation of specific phenomena and allow

comparison of different regions of parameter space associated with a particular phenomenon. Our increased knowledge of these disparate atmospheres when augmented by analytical models and laboratory data will lead to a greater understanding of the nature of our own atmosphere. The program consists of three tasks, one of which is a study of the comparative atmospheric dynamics; the remaining two are laboratory and theoretical determinations of the opacities of molecular hydrogen for the outer planets and of the optical properties of ices in the infrared.

**W77-70547** **185-47-58**
Goddard Space Flight Center, Greenbelt, Md.
**MINIATURE VACUUM PUMP DEVELOPMENT FOR NOBLE GAS PUMPING ON ATMOSPHERIC ENTRY PROBES ON OUTER PLANET MISSIONS**
H. B. Niemann 301-982-4706

The objective of this work is to develop efficient, low weight vacuum pumps for flight application with mass spectrometer experiments on atmospheric entry probes for outer planet exploration. The most abundant gases on the planets presently under consideration for direct probing are hydrogen and helium. While hydrogen can be pumped with relatively little effort to a pressure level suitable for mass spectrometer operation, the difficulties encountered in pumping helium effectively and reliably has become a major obstacle in the development of instruments for mass spectrometric composition measurements from atmospheric entry probes. Getter pumps or sputter ion pumps conventionally employed in flight mass spectrometers have none or very limited pumping capability for helium. It is proposed to do development work in two areas: (1) developing a low weight sputter ion pump with high specific pumping efficiency for helium, and (2) develop a miniature turbomolecular pump suitable for flight application which has no specific discrimination for noble gases.

**W77-70548** **185-47-66**
Ames Research Center, Moffett Field, Calif.
**ATMOSPHERIC CHEMICAL PHYSICS - PROCESSES IN PLANETARY ATMOSPHERES, COMETS AND INTERSTELLAR SPACE**
D. R. Chapman 415-965-5065

The objective is to determine products, rates, and yields of energy transfer reactions in planetary atmospheres, comets, and interstellar space. Solar and galactic radiations interact with the atmospheric constituents to produce excited and ionized species and free radicals, which then react to form other ionized and excited species, and/or neutral unexcited species, and/or reradiate spectral energy. Insight into the nature of planetary atmospheres, comets, and interstellar matter can be obtained from studies of these processes under controlled laboratory conditions. Investigations in the photochemistry of the CO2-rich atmospheres of Mars and Venus and other atmospheric processes involving optical emission and absorption will be conducted under controlled laboratory conditions. This study will consider also the effectiveness of minor constituents such as Cl, S, and OH in catalyzing reactions. The latter study is particularly relevant to the CO2 photochemistry of Venus. The ultraviolet photolysis of CH4, NH3, H2O and H2 will be investigated and the quantum yields and fluorescence cross sections determined. These studies will contribute to our understanding of the photochemistry of reduced atmospheres (e.g., Jupiter) and will provide scientific support for future planetary exploration.

**W77-70549** **185-47-67**
Ames Research Center, Moffett Field, Calif.
**STRUCTURE OF PLANETARY ATMOSPHERES**
D. R. Chapman 415-965-5065
(384-47-66; 170-36-56)

The basic goal is to connect atmospheric observations with theory. Immediate objectives are: (1) to define the structure of the ionospheres of Venus, Mars, Jupiter, and other planets, and the moons of Jupiter and Saturn, (2) to determine the interactions of planetary ionospheres with the solar wind, (3) to define the dynamics of the atmosphere of Venus and Mars, (4) atmospheric structure of the Jovian (planets and Titan, and (5) mean particle sizes and optical depth of Saturn's rings. All of this work is closely related to recent spacecraft missions, to programmed missions such as Venus Pioneer, or to missions in the study stage such as those to the outer planets. The abundances and distributions of ions, electrons, and minor constituents on Mars, Venus, the outer planets, and the moons of Jupiter and Saturn are being studied theoretically, using data from observations and laboratory measurements. In each case this work involves numerical solution of appropriate conservation equations. For example, in the case of Io we solved the complete set of coupled mass, momentum, and energy conservation equations for electrons, ions, and neutral particles. Thermal structure models have been constructed to understand the operation of the greenhouse effect on Titan. In order to understand the dynamics of Venus' atmosphere, calculations are being carried out to examine the effects of rotation, apparent solar motion, and the energy deposition profile on the circulation of the atmosphere. The Mintz-Arakawa model of the Earth's atmosphere is being adapted to the conditions on Mars to permit a calculation of the general circulation of the Martian atmosphere. Estimates of the particle size in the rings of Saturn are obtained from analysis of IR and microwave measurements.

**W77-70550** **185-47-68**
Ames Research Center, Moffett Field, Calif.
**PLANETARY ATMOSPHERES - STRUCTURE AND COMPOSITION**
D. R. Chapman 415-965-5065
(185-47-67; 185-47-69)

The ongoing OSS program to explore the planets includes two missions, Viking and Pioneer Venus, on which properties of the planetary atmospheres will be measured during entry and descent to the surface by instruments carried by the probes. These experiments have grown out of research supported by this RTOP. The continuing studies will optimize the approach and maximize the return related to atmosphere structure from the Viking Entry Science experiment, and will further develop the capabilities of the Pioneer Venus experiment. A major thrust of this work recently has been the relationship of measured parameters to the winds at the entry sites and the overall circulation of the planets' atmospheres. The further development of wind observational techniques will require continuing effort. Extension of experiment capabilities in several directions is also to be pursued. These include turbulence measurement, and its relationship to turbulent mixing and transport in the atmosphere; precise definition of molecular weight of hydrogen-helium atmospheres, as a means for defining the hydrogen-helium ratio; and definition of the probe mass loss as a function of time, to permit the experiments to be performed with precision on entries into the giant outer planets which are accompanied by large mass loss of the heat shield. In addition, some work will be devoted to study of composition experiments for missions to Saturn, Uranus, and Jupiter.

**W77-70551** **185-47-71**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ATMOSPHERIC EXPERIMENT DEVELOPMENT**
D. P. Burcham 213-354-3028

This work defines, develops and evaluates new or improved science experiments for the exploration and study of the atmospheres of solar system bodies from a spacecraft. The approach is through research in the following categories: (1) development and application of practical radiative transfer theory applicable to remote sensing experiments, (2) interpretation and critical analysis of existing data from planetary missions and Earth-based observations, (3) laboratory and theoretical studies of physical and spectral properties of atmospheric gas and cloud constituents relevant to specific experiment goals, and (4) participation in planning mission science by evaluating feasibility of key objectives using realistic technology within a framework of spacecraft and mission constraints. Instruments and techniques are developed via detailed numerical studies and error analyses and laboratory, ground based or airborne experiments as appropriate. Atmospheric models are developed and continually refined to maximize the realism and relevance of numerical work. Experimental techniques developed under this task are being implemented on Viking, MJS and Pioneer Venus. New and

continuing work for FY-TR and FY-77 centers on (1) an energy balance, atmospheric circulation and cloud structure experiment for the upcoming JOp mission, (2) an experiment for direct measurements of wind by remote sensing from orbit, (3) new methods for improving the vertical resolution of temperature soundings, (4) use of fluid dynamical models for the interpretation of Venus temperature soundings, (5) an expanded effort to obtain vital spectroscopic data on planetary gases and cloud constituents for data interpretation and experiment design, and (6) completion of laboratory experiments to define an instrument to measure the helium-to-hydrogen ratio in the Outer Planets by an alpha-scattering experiment on an entry probe.

**W77-70552** **185-47-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**THEORETICAL STUDIES - PLANETARY ATMOSPHERES**
D. P. Burcham 213-354-3028

A broad program of applied and theoretical studies related to planetary atmospheres will be conducted, with the following primary objectives; (1)understanding the properties and determination of the parameters of planetary atmospheres, (2) application of experimental data, both laboratory and astronomical, to the understanding and interpretation of spectral features and mechanisms for complex planetary atmospheres, (3) applying these findings toward design of ground based and spacecraft experiments, and (4) interpretation of above data as well as other observations to aid in the evolution of valid planetary atmospheric models. The studies to be conducted in FY-77 pertain to planetary atmospheric modeling, radiative transport theory, determination of millimeter and submillimeter spectra and the oretical spectroscopic development for studies of planetary atmospheres.

**W77-70553** **185-47-80**
National Aeronautics and Space Administration, Washington, D.C.
**EXPERIMENT DEVELOPMENT**
Robert F. Fellows 202-755-3660

The objective of tasks supported under this RTOP is to develop the instrumentation capability required for spacecraft exploration and study of planetary atmospheres and cometary gases. New concepts will be sought and evaluated, and known techniques and instruments will be modified and developed for specialized application. Studies essential to understanding the response and behavior characteristics of sensors and instruments will be conducted. Emphasis is being placed on three areas of development: (1) specialized sensors and instruments required for investigation of the lower atmosphere and cloud phenomena of Venus and Jupiter by entry probes, (2) instrumentation and experiments required for investigations of the atmospheres of the outer planets from flyby and orbiter spacecraft, and (3) design of experiments and instruments for the in situ investigation of the surface atmosphere of planets from landed spacecraft.

**W77-70554** **185-47-81**
National Aeronautics and Space Administration, Washington, D.C.
**THEORY AND MODELS**
Robert F. Fellows 202-755-3660

The objective of this RTOP is to foster and to develop a broad base of theory explaining the phenomena of planetary atmospheres including their origins, evolutions, present status, and future behavior. Theoretical models of the atmospheres of the planets are derived, modified, critiqued, and improved on a continuing basis using the fundamental principles of physics and chemistry supplemented by the most current information available from flight experiments, laboratory research, and astronomical observations.

**W77-70555** **185-47-83**
National Aeronautics and Space Administration, Washington, D.C.
**SPECTROSCOPIC INVESTIGATIONS**
Robert F. Fellows 202-755-3660

Work performed under this RTOP includes theoretical and laboratory investigations of the components of planetary atmospheres by spectroscopic, photometric, and radiometric techniques for the purpose of obtaining data necessary for the design of flight experiments and the interpretation of data obtained by flight experiments. Also included are the necessary studies in the theory of spectroscopy and radiative transfer necessary to interpret flight data in terms of physical properties such as temperature and density profiles in addition to the usual determinations of composition. The majority of tasks are concerned with infrared and ultraviolet spectroscopic studies of gaseous species although exploratory studies to define the potential of microwave techniques are also included. Tasks also include work directed at understanding auroral and airglow emissions since spectroscopic scrutiny of these natural processes offers strong clues to the composition and characteristics of the atomic and molecular species involved.

**W77-70556** **185-47-85**
National Aeronautics and Space Administration, Washington, D.C.
**ATMOSPHERIC CHEMISTRY**
Robert F. Fellows 202-755-3660

The objectives of this RTOP are to support a broad base program of laboratory investigations directed at obtaining data essential to the analysis of flight experiments and the development of new and improved theories and explanations of atmospheric chemical processes. Research included under this program includes investigations of chemical kinetics, photochemistry, reaction mechanisms, intermediates and metastable reaction species, collision processes and other phenomena connected with the interchange of energy between photons, atoms, ions, and molecules, and the interaction of such species with electromagnetic radiation. Also included is research concerned with determining the physical and chemical properties of low molecular weight molecules, free radicals, and other species stable at cryogenic temperatures that are likely to be present in comets or the atmospheres of the outer planets.

**W77-70557** **185-47-91**
Langley Research Center, Langley Station, Va.
**PLANETARY ATMOSPHERIC PROCESSES AND MEASUREMENTS**
P. F. Holloway 804-827-2893
(384-47-91; 385-36-01; 188-78-60)

Properties and processes of the Earth's upper atmosphere, as well as the atmosphere of other planets, are studied using ground-based and satellite measurements, laboratory simulations, and theoretical studies. Earth atmospheric measurements employing various techniques are compared with drag measurements of the NASA Langley Air Density Explorer satellites to obtain a more comprehensive picture of our thermosphere and exosphere. Theoretical and experimental studies of gas-surface interactions are also performed. A number of studies concerning atmospheric processes and measurements apply to other planetary atmospheres. Experimental studies are being performed on the properties of planetary atmospheres. Theoretical studies are being performed on the composition, density, temperature, and evolution of the atmospheres of Mars, Venus, and other planets and planetary satellites. Consultant work is performed on the drag effects of satellites orbiting Mars and Venus.

**W77-70558** **185-50-60**
Ames Research Center, Moffett Field, Calif.
**PLANETOLOGY: SURFACE PROPERTIES OF PLANETS**
D. R. Chapman 415-965-5065

The objectives are to: (1) study the relative expressions of the impact process on the production of surface features of the inner planets and their satellites, and to (2) determine parameters governing aeolian processes in various planetary environments by means of wind tunnel and earth analog studies. The approaches will be to (1) characterize morphology and size frequency distributions in different morphologic units of Mercury to reconstruct its surface history, (2) conduct experiments using the Martian Surface Wind Tunnel to study threshold and to model erosion and deposition around landforms; perform field studies of aeolian features at terrestrial analogs; and analyze images of Mars to study aeolian features, and (3) perform photo-geological analyses of Martian, Mercurian, and lunar

surfaces using laboratory cratering data to determine the nature of the late heavy bombardment and the extent of atmospheric obliteration on Mars.

**W77-70559** **185-50-61**
Ames Research Center, Moffett Field, Calif.
**THEORETICAL STUDIES OF PLANETARY BODIES**
D. R. Chapman 415-965-5065

The objective is to obtain a better understanding of selected problems pertaining to planetary surface phenomena, the composition, structure and evolution of planetary bodies and their satellites, and the origin of the solar system by means of theoretical investigations employing the results of spacecraft and ground-based experiments. Theoretical knowlege, physical insight, and mathematical modeling techniques are used, together with astronomical and geological data, to construct self-consistent mathematical descriptions of planetary processes and structure. Analysis and interpretation of the results of these model calculations are applied to such topics as, the evolution of Jupiter, wind-blown surface features on Mars, and the calculation of conditions within the early solar system.

**W77-70560** **185-50-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PLANETOLOGY STUDIES**
D. P. Burcham 213-354-2038

We are continuing our program to study the spectral reflectance properties of various ices of outer planet and cometary interest for use in comparison with telescopic data. We propose to measure the infrared (1.0 - 5.0 micron) reflection spectra of pure ices (water, methane, ammonia, etc.) and mixtures of these ices (hydrates, clathrate hydrates, etc.), as well as mixtures of ices and salts. Transmission spectra will be used to study regions of weak absorption. The major applications of this study will be: (1) reflection spectra will be used directly for comparison with telescopic observations of solar system objects for the determination of the chemical composition of their surfaces, and (2) the complex refractive indices of the ices will be determined from the reflection and transmission spectra. These results will be used to calculate scattering properties for modeling of particulate surfaces and planetary atmospheres. (3) The scattering properties will also be used for determination of the absorptional emission properties of small ice particles (as in comets) from which lifetimes of particles can be determined.

**W77-70561** **185-50-73**
Goddard Space Flight Center, Greenbelt, Md.
**INSTRUMENTATION DEVELOPMENT FOR INNER AND OUTER PLANETARY MISSIONS**
J. I. Trombka 301-982-5941

The objective of the work is to develop instruments to study the elemental composition of the surfaces of both the inner planets and Galilean moons. This also includes laboratory measurements to understand the interactions between incident photon and particle fluxes and the planetary surfaces. Principal effort will be in designing instruments which can measure x-ray fluxes from the Galilean moons in a high electron flux environment. The possibility of utilizing neutron-gamma techniques for penetrometer missions will also be considered. Both theoretical calculations and field experiments will be used in the study. The X-ray work will first emphasize the calculation of X-ray fluxes, while the neutron-gamma ray work will utilize already existing equipment for field studies. The laboratory studies of interactions on the planetary surface will use the ESSCA system available at GSFC.

**W77-70562** **185-50-73**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PLANETOLOGY INSTRUMENT DEVELOPMENT**
D. P. Burcham 213-354-3028

The X-ray Diffractometer/Spectrometer task has been devoted to the development of an instrument capable of performing a combined mineralogical and elemental analysis on the Martian surface or other planetary body with a solid surface. In the absence of sufficient funding to fabricate an engineering model, the program is at a minimum level following laboratory work to match performance with the science rationale, the evaluation of certain interfaces and on preliminary design of the sensor portion. The present objectives are to complete the laboratory studies of energy-dispersive analysis and publish past results.

## Planetary Exploration SR&T - Advanced Technical Development

**W77-70563** **186-68-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**IMAGING SYSTEM TECHNOLOGY FOR PLANETARY MISSIONS**
R. R. McDonald 213-354-6186
(185-50-73; 506-18-11)

The objective of this program is the development of Imaging Instrument technology using line and area-array CCD (Charge Coupled Device) sensors. Expected advantages of cameras using these sensors, compared to current technology, are extended red and near-IR response, increased sensitivity and dynamic range, improved geometric fidelity, lower cost, lower instrument weight, decreased power, and a simpler interface adaptable to different types of spacecraft. The camera developments will be coordinated with the development of CCD sensors, with the objective of developing reasonable resolution line and area-array cameras for use on proposed missions in the early 1980's. Fabrication of the initial line and area-array cameras has been completed. Testing and evaluation are underway, and advanced design using improved sensor configurations is underway.

**W77-70564** **186-68-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GUIDANCE AND CONTROL TECHNOLOGY FOR PLANETARY MISSIONS**
R. R. McDonald 213-354-6186
(506-19-14; 506-19-21)

The objective of this work is to make available a planetary star tracker suitable for interplanetary spacecraft applications. This work will also provide the technology base for a standardized low cost star tracker for broad application to anticipated NASA missions beginning in 1980. This star tracker has been designated by the acronym STELLAR for 'Star Tracker For Economical Long Life Attitude Reference.' The STELLAR makes significant improvements in reliability by utilizing an all solid-state image sensor thereby completely eliminating high voltage circuitry and vacuum tubes as used in current star trackers and in addition provides significant reductions in cost, size and weight. The STELLAR concept is a revolutionary (rather than evolutionary) departure from current star trackers and is keyed directly to the fast emerging new technology of Charge Coupled Device (CCD) photodetectors. The objective of the STELLAR development effort is to achieve the improvements in reliability (10 year lifetime vs 3 years), performance and cost (over 50% reduction in sensor costs) and to demonstrate these improvements in an engineering model STELLAR. The FY-TR and FY-77 objective of this RTOP is to perform the detail design of a planetary STELLAR star tracker engineering model. The engineering model will then be fabricated and tested to functional requirements generated under the program to develop an Extended Life Attitude Control System (ELACS).

**W77-70565** **186-68-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**G&C TECHNOLOGY FOR MARS ROVING VEHICLES**
R. R. McDonald 213-354-6186

The work proposed in this RTOP will provide technical assistance and direction to the NASA Headquarters University Grant NGL 33-018-091. This grant is to Rensselaer Polytechnic Institute for development of component and system technology for Mars Roving Vehicles. The JPL effort will consist of reviewing the work at RPI as well as correlating RPI's effort with ongoing work at JPL. It is understood that NASA will end the work in FY-77. RPI will have completed the testing of a

Viking scale Mars Roving Vehicle under autonomous computer control.

**W77-70566** **186-68-62**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PROPELLANT COMPATIBILITY WITH MATERIALS FOR LONG DURATION MISSIONS**
R. R. McDonald 213-354-6186

The objective of this work is to provide the technology for propellant/material compatibility that will be used on future planetary missions. Current objectives include work to determine which materials are acceptably inert for use in the construction of propulsion subsystem components in contact with earth storable liquid propellants for long duration missions. The test program involves continuing actual specimen storage tests in a controlled environment using the compatibility test facility at the JPL Edwards Test Station. Detailed chemical and physical analyses of specimens and propellants will be performed after specific storage periods and a rating assigned for design purposes.

**W77-70567** **186-68-74**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SOLAR ELECTRIC PROPULSION - NAVIGATION AND MISSION ANALYSIS**
R. R. McDonald 213-354-6186
(506-19-21)

The objectives are development of a comprehensive navigation accuracy analysis software system for low thrust missions and the exercise of that software for the generation of navigation accuracy forecasts and requirements for advanced SEP missions and the development, testing, and evaluation of navigation strategies incorporating advanced data types and filtering techniques; and development and utilization of a comprehensive mission analysis capability for determination, evaluation, and study of low thrust (both SEP and NEP) mission concepts. Documentation of the existing navigation software system will be upgraded, and capabilities will be expanded to narrow the gap between 'conservative' and 'realistic' analysis capability for future missions. Limited navigation analyses will begin. Performance software to accurately simulate the low thrust hardware system and assess mission impacts of various operational strategies and constraints will be used to develop data to a limited extent for missions, such as comet rendezvous. Because gravity-assist offers substantial energy-saving benefits, a rapid, inexpensive algorithm for gravity-assist combined with low thrust will be sought. Active cognizance over the software will be maintained to allow a timely response, on a limited scale, to questions that may arise in connection with preliminary mission performance studies or thrust subsystem development.

**W77-70568** **186-68-75**
Ames Research Center, Moffett Field, Calif.
**OUTER PLANET ATMOSPHERIC PROBE DEVELOPMENT**
D. R. Chapman 415-965-5065
(186-68-65)

The objective is to develop a common outer planet entry probe system capable of performing exploratory atmospheric definition studies of Saturn, Uranus, and, with suitable modifications, of Jupiter. The baseline design will make maximum use of existing technology (i.e., PAET and Pioneer Venus instruments) and shall also be designed to be compatible with either the Pioneer or Mariner spacecraft. In-dept technical and cost information will be generated for the system configuration corresponding to each mission in order to provide early, realistic project definition data required for management decisions regarding both the scope and timing of future scientific investigations of the giant outer planets. The basic approach is to conduct a combination of end-item oriented analyses and focused tests of the critical probe subsystems. The resulting calculations and experimental data are being used as input for two competitive mission definition studies that will provide a detailed probe system design along with appropriate trade-off data. Emphasis throughout the supporting research and definition study phases will be to quantify the impact of the various mission options upon both the cost and system requirements on the final hardware execution phase.

**W77-70569** **186-68-76**
Ames Research Center, Moffett Field, Calif.
**PLANETARY SURFACE PENETRATOR TECHNOLOGY**
Dean R. Chapman 415-965-5065

Recent studies have shown that surface penetrators are attractive tools for exploring the solid bodies of planets and satellites. Several aspects of the instrument's design and regolith modification caused by penetration must be assessed before a penetrator mission can be approved. Studies and tests will be performed to confirm the survival of several candidate science instruments and to measure the amount of change produced in the regolith by penetration. Critical subsystems will be developed to assure that they will perform acceptably for the mission. The electrical power which can be made available depends on the means for controlling penetrator temperature. This and other factors which will provide rigid payload and system constraints will be pursued.

**W77-70570** **186-68-83**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**JUPITER ORBITER PARTS RADIATION HARDENING**
Rob Roy McDonald 213-354-6186
(506-18-34)

The objective of this program is to develop electronic components and circuits capable of surviving in the Jupiter radiation environment. During FY-76 a plan was developed for hardening and making available for procurement those electronic components considered to be essential to accomplish a meaningful Jupiter Orbiter program. The plan is to be implemented during FY-77 and FY-78 with the cooperation of semiconductor houses and other government agencies.

**W77-70571** **186-68-84**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**TECHNOLOGY DEVELOPMENT FOR CONTROL OF POTENTIAL OF INTERPLANETARY SPACECRAFT**
R. R. McDonald 213-354-6186
(506-16-39)

The objective of this RTOP is the development of the technology necessary to minimize the electric fields surrounding a planetary spacecraft and to prevent extreme conditions of spacecraft electrostatic charging. The program will involve both the evaluation of the factors which produce electric fields on spacecraft and the development of the technology necessary to discharge the spacecraft in a controlled manner. Test will be performed to evaluate candidate techniques for releasing ions and electrons in a controlled manner from a spacecraft. The most promising techniques will be chosen for optimization studies. As a parallel effort, it will be necessary also to evaluate and optimize suitable electric field detectors for use in control configurations with the release devices. Finally, a breadboard system that can control spacecraft potential and be used on spacecraft such as MJO or PJO will be fabricated and evaluated. The work being done under the NASA LeRC program and the Air Force SCATHA satellite program, both of which will study S/C charging for earth-orbiting satellites, will be followed closely and factored into the JPL program where applicable.

**W77-70572** **186-68-85**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SATELLITE TOUR MISSION ANALYSIS AND NAVIGATION TECHNOLOGY**
R. R. McDonald 213-354-6186
(506-19-21)

This RTOP proposes to advance navigation technology to perform Jupiter Orbiter Satellite Tour (JO/ST) class missions. It is important to note that the fundamental navigation technology required for a JO/ST mission is independent of the spacecraft class, i.e., Mariner or Pioneer, since the feasibility issues are the same. The objectives are to: (1) develop new orbit mechanics technology for multi-encounter mission design and navigation strategy development, (2) define and develop navigation technology focused toward a JO/ST'81 mission. The task involves a focusing of recent techniques developed in NASA RTOP 502-33-91 in FY-74 and subsequently within RTOP 506-19-21 in the areas of multiple maneuver strategy development, advanced

estimation development, performance prediction technology, and JO satellite ephemeris development to the JO/ST mission. In addition the remaining technical development area is addressed by improving trajectory techniques to include third body acceleration effects in the determination of JO/ST flight paths. The goal is to produce cost effective and accurate software capable of: (1) generating accurate satellite tour flight paths from sample, point-to-point conic tour sequences, (2) calculating the placement in time of all orbit trim maneuvers, (3) assessing the performance and cost of implementing different maneuver strategies in terms of the required fuel allotment and the required tracking support patterns, and (4) predicting the flight path delivery accuracy for science reconnaisance at the satellite encounters for all tour designs.

**W77-70573** **186-68-86**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**TECHNOLOGY DEVELOPMENT FOR SHUTTLE - LAUNCHED PLANETARY SPACECRAFT**
R. R. McDonald 213-354-6186

The long range objective of this RTOP is to develop information useful in solving a wide variety of new problems which will be incurred as a result of launching planetary spacecraft via the Space Transportation System. Many problems have been identified in recent broad studies and, in some cases, preliminary solutions have been generated. This RTOP will provide increased depth of study of critical problem areas and will produce general design information forming the foundation for subsequent pre-project and project activities. The FY-77 objective will be to develop generalized design data and information for RTG cooling devices and protective shrouds for shuttle launched planetary payloads. Specifically the plan is: (1) to develop RTG cooling and payload shroud design alternatives by using compatible payload designs identified in various planetary mission studies; (2) to identify problem areas and assess their impact on Shuttle Orbiter and Interim Upper Stage, as well as on payload interfaces and operations; and (3) to identify specific design options for RTG cooling devices and shrouds requiring additional in-depth study and analysis. This RTOP will build on the results of previous and ongoing related JPL study activities, i.e., current mission and system studies, STS/Planetary Mission Operations Concept Studies, Study of Methods of Providing Thermal Control of RTG's for NASA payloads, and others. In FY-77 this RTOP will focus specifically on a Jupiter Orbiter/Probe mission. Specific payload modifications that facilitate payload/RTG cooling and shroud integration and overall STS operations will be analyzed.

**W77-70574** **186-68-87**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ORBITER MISSION COMMONALITY STUDIES**
R. R. McDonald 213-354-6186

The objectives are to establish commonalities at each level for orbiter missions and systems, to identify alternate ways of implementing these commonalities and to describe in some detail and evaluate the promising commonality alternatives. The approach will be the phasing of the various orbiter mission activities for the several planets. With the completion of the currently underway Mercury Orbiter Study, it becomes timely to undertake appropriate Orbiter Commonality Studies beginning in the FY-76 Transition Period and continuing through FY-77 and FY-78. Two phases of study effort are proposed: a Phase I effort devoted to establishing commonalities at each level of the orbiter missions and systems and identifying alternative ways of implementing these commonalities within the planetary exploration program; and a Phase II effort which undertakes to describe the promising alternatives to sufficient design depth to allow programmatic evaluation in terms of performance and capability, schedule, resource requirements, and risk.

**W77-70575** **186-68-88**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**MISSION AND SYSTEM DESIGN - OPOP(J)**
R. R. McDonald 213-354-6186

The objective of this RTOP is to accomplish the mission and spacecraft system design for a Jupiter Orbiter with Probe mission in early 1982. The OPOP(J) spacecraft design is an adaptation of a dual spin spacecraft. The spacecraft carries field and particle instruments and the probe on its spin section. Remote sensing instruments and the probe relay communications antenna are carried on a pointable (clock, cone) despun section. The details of the design concepts in both a spacecraft system and subsystem context will be accomplished and ultimately, a spacecraft system design will be defined. Mission design will be undertaken with initial efforts directed to those mission definition activities required to support the Jupiter Orbiter Science Working Group. Mission design activities will conclude with a finalized mission design at the time science confirmation is made. The approach to be taken will be to form two design teams to accomplish the mission and spacecraft system design. The teams will be comprised of personnel representing Science, Orbiter (JPL), and Probe (Ames). Team representation will also include technical disciplines, (e.g., radiation analysis) having a major involvement in the design and science payload definition activities. The teams will operate under the direction of designated team leaders and by means of regularly scheduled meetings.

**W77-70576** **186-68-89**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**MICROPROCESSOR BASED TERMINAL MODULE FOR OPO/P(J)**
R. R. McDonald 213-354-6186
(506-20-11)

The control and data handling system for the Outer Planet Orbiter/Probe (J) Spacecraft employs a distributed organization which utilizes two types of microprocessor modules which are nearly identical in structure. Terminal Modules (TM), located within science instruments and engineering subsystems, are utilized for local control and data gathering. High Level Modules (HLM) are utilized for macro-control, e.g., to coordinate the functions of the Terminal Modules. The basic system architecture is being developed under RTOP 506-20-11 with possible future support from the NASA Low Cost Systems Office. The objective of this RTOP, in conjunction with RTOP 506-20-11, is to design the basic microprocessor Terminal Module (TM) to be used in the OPO/P(J) spacecraft control and data handling system. This task will consist of the following activities: (1) selection of a microprocessor and other LSI/hybrid components with the necessary functional capabilities and radiation resistance to satisfy the OPO(J) mission requirements, (2) design of standard circuits for interfacing the Terminal Module with OPO(J) subsystems or instruments, sensors and actuators, (3) design of intercommunications bus interface to the Terminal Modules, and (4) Terminal Module packaging design.

**W77-70577** **186-68-90**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**DUAL SPIN ATTITUDE CONTROL FOR OUTER PLANET MISSIONS**
R. R. McDonald 213-354-6186
(509-19-14)

The purpose of this RTOP is to determine the advantages, limitations and configuration constraints that a dual spin attitude control concept may have for Outer Planet Missions. Particular attention is focused on a Jupiter Orbiter/Probe Mission. The fundamental difference of dual spin control from simple spinners is that part of the spacecraft is de-spun so that a platform exists which is in effect three axis stabilized. In one vehicle, the advantages of spin stabilization and three axis control are realized. The dual spin control concept was recognized long ago as an excellent approach to Earth orbiters having requirements exceeding the capability of simple spinners. A notable commercial example is the INTELSAT series. The objectives of the RTOP are to develop a variety of mechanizations and control laws for active inertial and center of mass control and various control modes; analyze effect of and minimize dynamic interactions; determine and minimize pointing errors affecting maneuvers, instrument pointing and high gain antenna pointing; and make hardware assessments and tradeoffs according to requirements. The approach will be to extend present technology to Outer Planet missions. In particular the problems of spin stabilization of large masses of liquid propellant and the interaction with large multiple thrusters must be examined. In addition, an instrument pointing mount on the

de-spun platform requires careful assessment. Specific hardware tradeoffs will be made. Comprehensive digital computer simulations will be conducted to analyze the complex dynamics and highly interactive parts of the spacecraft system.

**W77-70578** **186-68-91**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PROJECT SCIENCE GROUP SUPPORT - OPO/P(J)**
R. R. McDonald 213-354-6186

During FY-77 tentative selection will be made of the investigations for the Outer Planets Orbiter/Probe (Jupiter) OPO/P(J) mission. This selection will be made on the basis of the evaluation of proposals received in response to Announcement of Opportunity no. OSS-1-76. Following selection on about March 1, 1977, the Principal Investigators will be formed into a Project Science Group (PSG) for the OPO/P(J) mission. The purpose of this RTOP is to provide funding for this PSG. Contracts will be let to each investigator to support his activities during the mission definition phase leading to the final selection/confirmation of investigations.

## Physics and Astronomy

**W77-70579** **188-41-51**
National Aeronautics and Space Administration, Washington, D.C.
**ULTRAVIOLET (UV) AND OPTICAL ASTRONOMY**
J. D. Rosendhal 202-755-3687

The objective is the advancement of stellar and galactic astronomy through observations and interpretations of data secured in the ultraviolet and visible electromagnetic portions of the spectrum. The emphasis is on research in direct support of on-going flight programs or in anticipation and preparation for future ones. The four elements supported are laboratory astrophysical studies, theoretical astrophysics, instrumentation development, and direct observational programs. A balanced program involving all these elements is required in order to insure full utilization and healthy development of the space science order to insure full utilization and healthy development of the space science program with the goal of the advancement of our understanding of the universe. The approach is to develop theoretical models, perform theoretical studies, and determine basic atomic and molecular parameters. Interpretation of data, especially that obtained in the relatively unexplored UV spectral region, requires the additional information provided by these efforts. A broad and sound theoretical framework allows new observations to be interpreted and new directions to be instituted. In addition to atomic and molecular physics, specific areas of study include stellar atmospheres, stellar systems, and cosmology

**W77-70580** **188-41-51**
Ames Research Center, Moffett Field, Calif.
**THEORETICAL ASTROPHYSICS**
D. R. Chapman 415-965-5065

The objective of this work is to conduct theoretical studies on important fundamental problems in astrophysics and astronomy and to provide theoretical support for the ARC program in observational infrared astronomy. Although a wide range of astrophysical phenomena are under investigation, research efforts are primarily directed towards infrared astronomy and computational astrophysics. Theoretical work in infrared astronomy includes modelling of circumstellar shells in Be and T-Tauri type stars, studies of fragmentation of interstellar clouds and subsequent collapse to the main sequence, post-eruption evolution of novae, and the development of a numerical code for investigating atmospheres of late-type stars, as well as data analysis and interpretation of airborne infrared observations. The computational astrophysics underway treats a broad spectrum of gas dynamic and hydrodynamic problems in astrophysics including pre- and post-main sequence evolution, accretion, the evolution of spiral galaxies, and the dynamics of gas acceleration near OSO's.

**W77-70581** **188-41-51**
Marshall Space Flight Center, Huntsville, Ala.
**UV AND OPTICAL ASTRONOMY**
C. R. O'Dell 205-453-0162

We will continue to pursue an observational and interpretative program of astronomical spectroscopy using the Echelle grating nebular spectrograph. This will include the mainline program on internal velocities in HII regions, a search for velocity shifts and spectral features in the zodiacal light and near infrared spectra of comets. The method of post development image enhancement of photographic film by means of autoradiography will be further developed to select optimal films for groundbased and Spacelab astronomical experiments. The objective of this task is to obtain and interpret observations of astronomical X-ray sources, such as globular clusters. The approach will be to continue to utilize the integrating digital video detector system, which offers the advantage of high temporal resolution. Photon counting techniques utilizing photomultiplier tubes are also planned for observations requiring higher sensitivity.

**W77-70582** **188-41-51**
Lyndon B. Johnson Space Center, Houston, Tex.
**ULTRAVIOLET STELLAR SPECTROMETER DEVELOPMENT FOR SPACE SHUTTLE**
White D. Kondo 713-482-6467

The objectives are to develop UV instrumentation for use in Shuttle Sortie missions, which will demonstrate state-of-technology detector and tracking performance, flexibility of interfacing instrumentation with a general purpose telescope platform, and versatility of man's real time operational involvement. The development of the ultraviolet stellar spectrometer for space shuttle is performed through the flights of the Balloon-borne Ultraviolet Stellar Spectrometer (BUSS) payload as well as through other concurrent laboratory-based developments. The BUSS payload performs high resolution spectrophotometry of astronomical objects in the mid-ultraviolet. The first version of the BUSS payload has been developed and flown successfully four times. It comprises a pointable telescope (40 cm aperture, f.7.5 modified Ritchey-Chretien) to which a variety of instrumentation can be attached. Payload functions are commanded from the ground in real time, and the data are telemetered to the ground in real time, where they are monitored in real time and recorded. Further development of the payload has been accomplished in conjunction with the collaborative program with the Space Research Laboratory, Utrecht, the Netherlands. In this collaborative program, we are jointly investigating stellar UV spectra in the range 2000-3400A with a resolution of 1/1A, employing an echelle spectrograph in combination with an image intensified storage vidicon detector. Subsequent flights will develop the star tracking system for targets as faint as 10th magnitude and for improved spectral resolution.

**W77-70583** **188-41-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**UV AND OPTICAL ASTRONOMY**
D. P. Burcham 213-354-3028

The objective of this task is to obtain laboratory data on ion-molecule reactions of importance to the synthesis of molecules detected in interstellar condensations. The facilities of the JPL ion chemistry laboratory, in particular the ion cyclotron resonance (ICR) instrument, are emminently suited for this work. In addition, a theoretical program has been written by S. Prasad (RRA) to simulate chemical evolution in these clouds based both on laboratory data and on chemical intuition where the data is presently unavailable. In FY-TR and FY-77 work will continue to provide laboratory data for this program and for academic workers in this field with whom we maintain a working relationship (Watson, Dalgarno, Langer). Interstellar plasma is electrically neutral, wherever there is a positive ion in the medium there is an electron or negative ion. The electron-moleculer interactions (rotational, vibration and electronic excitation), dissociation, dissociative attachment, and photon emission processes which play an important part in interstellar chemistry will be studied. The methods of crossed-beam electron-impact spectroscopy will be used to identify metastable states of molecules which are not observable by photon excitation. Measurements of absolute

cross sections for elastic and inelastic scattering of electrons with energies of 0-100 eV by the interstellar species H2O, HCN, NH3, CO and potassium will be studied. These data will be correlated and presented with all available experimental and theoretical data. A new electron impact apparatus is being assembled and tested which incorporates a radical source; and a tunable dye laser for generating excited target species and for serving as a diagnostic tool in electron scattering experiments. This new instrument-financed through a grant from the Caltech President's Fund - will provide new capabilities for measuring e-molecule, atom, or radical interactions.

**W77-70584** **188-41-52**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GROUND-BASED RADIO ASTRONOMY**
D. P. Burcham 213-354-3028

This RTOP combines various NASA-JPL facilities in a program of ground-based radio astronomy. NASA's Deep Space Network provides unequalled sensitivity at 2.3, 8, and 15 GHz, supporting sensitive astronomical observations. JPL's Division 33 represents a pool of technical resources which permit innovative radio astronomy programs. In JPL's Planetary Atmospheres Section, a microwave spectroscopy laboratory measures frequencies, absorption coefficients and cross-sections for molecules of interest to astrophysics and supports the observational program by compiling data on such molecules. During this year, the results of a millimeter-wavelength receiver development program will also become available for interstellar microwave spectroscopy. The program is directed at fundamental questions of galactic and stellar evolution. Observations of regions of suspected star formation, and in particular the analysis of the shapes of spectral lines, is leading to an understanding of the processes of star formation. Similar observations are also important for the understanding of late stages of stellar evolution, when copious mass-loss leads to the formation of planetary nebulae and similar objects. Interferometric observations of compact radio sources, such as compact H II regions, mass-loss stars, flare stars, and X-ray stars focus on other stages of stellar evolution. The conditions in comparatively inactive regions in interstellar clouds are also being probed, using observations of molecules (e.g. CO, H2CO and of ionized matter H(+), C(+), S(+). In attempting to arrive at a better understanding of interstellar chemistry and its bearing on stellar evolution, searches for new molecules are conducted, as well as efforts to identify current 'unknown' lines. In support of the line search/identification program, a computer-based catalogue of microwave transitions will be generated. It will be possible to access this catalogue remotely via telephone in direct support of observational programs.

**W77-70585** **188-41-54**
Marshall Space Flight Center, Huntsville, Ala.
**RELATIVITY AND CELESTIAL MECHANICS**
Richard A. Potter 205-453-3431

The objective of this activity is to develop, through a coordinated program, the technology and research required to support the flight of the gyro-relativity experiment. This experiment will be a fundamental and unique test of the general theory of relativity. The feasibility of this experiment centers around the development of a cryogenic gyroscope several orders of magnitude more precise than any existing, and the ability to maintain these gyroscopes and record their precessions, while in earth orbit, over a period of three months or more. The work, requiring advancement in several disciplines, is being accomplished by complementary efforts at MSFC, Stanford University and the University of Alabama in Huntsville. This work is a well coordinated, theoretical, experimental and engineering program oriented toward a satellite flight that will establish the validity of the General Theory of Relativity.

**W77-70586** **188-41-54**
National Aeronautics and Space Administration, Washington, D.C.
**RELATIVITY**
N. G. Roman 202-755-3649

The primary objective is to make experimental tests of the theory of relativity and thereby elucidate the interrelationship among space, time, and gravity. In particular, the test of Einstein's General Theory of relativity is paramount. This formulation is fundamental and of high scientific interest. Experimental verification is difficult but the ability to orbit large, complex, and extremely precise apparatus, shielded from deleterious perturbations should obviate them. In addition to the scientific goals, improvements and innovations in the technological areas of cryogenics, gyroscope design, and precision clocks are expected. Specific objectives include the development and operation of a flight qualified cryogenic gyroscope, complete gyroscope system error analysis, and the consideration of various theoretical formulations of relativity and their subsequent experimental implications. Possible future benefits apart from the scientific ones include improved timing for navigation, communication and geodesy as well as cryogenic systems capable of extended operation in space.

**W77-70587** **188-41-54**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**RELATIVITY**
D. P. Burcham 213-354-3028

The astrophysical consequences of 'missing matter' in the universe is being studied, first by formulation of general models with conducting plasma matter content. This research will support interpretation of data on intergalactic matter, its composition, excitation and ionization history, which will result from far ultraviolet quasar spectra taken with the forthcoming IUE satellite. The solution of Einstein's equations for selected anisotropic cosmological models is being investigated. Consequences for observational cosmology have been considered. This research has supported a study and proposal for measurement of large scale anisotropy of the Cosmic Microwave Background Radiation to be made from an Explorer satellite. Advances in techniques of nonlinear applied mathematics are being applied to selected problems of relativistic gravity, in particular to the calculation of fields of axisymmetric spinning sources, and to gravity waves. Research is being performed on the interaction of gravitational radiation with Doppler spacecraft tracking measurements, and on possible detection of gravitational radiation by simultaneous tracking of several spacecraft.

**W77-70588** **188-41-55**
Ames Research Center, Moffett Field, Calif.
**INFRARED EMISSION LINE POLARIZATION ASTRONOMY**
D. R. Chapman 415-965-5065

The objective is to study the magnetic field properties of infrared astronomical sources and to interpret the results in terms of the astrophysical mechanisms and compositions associated with these observed objects. The approach is to observe the Zeeman splitting and polarization of forbidden lines in HII regions and planetary nebulae and from these observations determine the general characteristics of the magnetic field and its effect upon the geometry and the matter and radiation transport within the source region. A Fabry-Perot interferometer and polarimeter will be used at a ground-based observatory to measure the strength, line shape, Zeeman splitting and polarization of the collisionally excited forbidden lines. By observing the magnetic field characteristics associated with several different infrared objects it may be possible to determine its effect on the dynamics of possible star forming regions.

**W77-70589** **188-41-55**
National Aeronautics and Space Administration, Washington, D.C.
**INFRARED ASTRONOMY**
N. W. Boggess 202-755-3688

The objective is to advance stellar and galactic astronomy in the spectral region between 1 and 1000 microns through observational and theoretical programs. Observations in the infrared portion of the electromagnetic spectrum are particularly important for an understanding of the early and late stages in stellar evolution, interstellar matter, galaxies and quasistellar objects and the energy mechanisms associated with them, and the residual radiation of the universe. A balanced program including observation, technique and instrumentation development, and theory is required to insure the advances needed for full utilization

of future platforms in space. The approach includes the following elements: (1) support observational programs using ground-based telescopes, balloons, and airplanes, and (2) to promote the development of infrared techniques and apparatus. Special emphasis is placed on far IR narrow band filters, spectral interferometers, modulation techniques, and multiple detector arrays in order to enhance the information content of an observation; and more recently, on development of cryogenic and low-background telescopes.

**W77-70590** **188-41-55**
Goddard Space Flight Center, Greenbelt, Md.
**FAR INFRARED ASTRONOMY**
M. G. Hauser 301-982-4679

The scientific objective of this program is to observe stellar, interstellar and extragalactic sources of far infrared (10-1000 micron) radiation in order to study many astrophysical problems, such as early and late phases of stellar evolution, the composition and dynamics of the interstellar medium, the energetics of high luminosity galactic and extragalactic sources, and the structure and history of the universe. Since atmospheric opacity and emissivity prohibit or severely limit ground-based observations, high altitude observational platforms such as balloons and satellites must be developed to permit sensitive astronomical measurements in this spectral range. High detectivity composite bolometers will be developed to take maximal advantage of the low background conditions achievable at these altitudes.

**W77-70591** **188-41-55**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**INFRARED ASTRONOMY**
D. P. Burcham 213-354-3028

The objective of this task is to obtain and analyze absolutely-calibrated high-resolution near-infrared (1 - 6 micron spectra of late-type stars and variables. The program is a collaborative effort between JPL and the University of Texas at Austin and involves a joint observing program using the JPL Fourier Spectrometer at the 2.7 m telescope, McDonald Observatory, model atmosphere analyses and spectrum syntheses in Austin, molecular physics at JPL and stellar interior modeling at JPL. From these data, we hope to learn more about the composition, structure and evolution of these objects.

**W77-70592** **188-41-56**
Goddard Space Flight Center, Greenbelt, Md.
**EMISSION LINE SPECTROSCOPY OF HIGH TEMPERATURE PLASMAS**
R. W. Hobbs 301-982-2591

The objective of this research is to observe high temperature plasmas with imaging detectors to determine astrophysical quantities in supernovae remnants, active galaxies and the interstellar medium. The observations will also provide emission line data complementing IUE hot star interstellar absorption data, and supporting HEAO, especially LOXT consortium spectroscopy. This research will also be important in instrument definition for future shuttle-based astronomical observations. The approach is to develop and use differential imaging detection systems in the photon counting mode. This instrumentation will consist of image intensifiers followed by solid state image detectors and dual solid state memories.

**W77-70593** **188-41-58**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SUPPORTING TASKS (ASTRONOMY)**
D. P. Burcham 213-354-3028

The objective of this task is to continue an effort initiated at JPL's Image Processing Laboratory during FY-76 under sponsorship of the JPL Director's Discretionary Fund to assess the applicability of digital processing technology developed in support of NASA's Planetary Program to the analysis of astronomy imaging data. In particular, the FY-76 activities were conducted with Dr. Arp of Hale Observatories, and it is proposed to broaden the interaction with the scientific community during the proposed activity. In addition, it is proposed that experienced image processing personnel from the Image processing Laboratory continue to serve in an advisory role for planning activities currently underway for the Space Telescope project, through involvement with the Data Management and Operations Team, the Project Scientist, and the Space Telescope Science Investigators. JPL personnel would also critique the ground data system design for Space Telescope as it evolves, as well as the sensor development and calibration activities, to insure that the stringent scientific requirements will be met. As part of this activity, existing algorithms will be applied to ground-based astronomical imagery to determine algorithms that maximize scientific benefits from digital processing of the imagery. (1) J. Lorre, D. Lynn, W. Benton, 'Recent Developments at JPL in the Application of Digital Image Processing Techniques to Astronomical Images', Optical Society of America Topical meeting on image processing, Asilomar, February 1976, J.Opt. Soc.Am., Feb. 1976.

**W77-70594** **188-45-51**
Goddard Space Flight Center, Greenbelt, Md.
**COMETS AND INTERSTELLAR MATTER**
B. D. Donn 301-982-5014

This RTOP includes several programs to study comets and interstellar matter. The primary objective is laboratory experimentation relevant to the physicochemical behavior of matter in space. Theoretical analysis of astronomical and space problems using experimental and theoretical results is a second aim. A third aspect involve ground based telescopic observations. The last phase uses observations from spacecraft to obtain otherwise unavailable data. The laboratory investigations make use of several new techniques, resonance fluorescence-flash photolysis, tunable laser spectroscopy from ultra violet to infrared and infrared heterodyne spectroscopy. These are used to study the production and reactions of atoms and radicals from planetary, cometary and interstellar molecules. Well established procedures are also used. High resolution spectroscopy is employed to determine absorption coefficients of the above molecules in the vacuum ultra violet. Thermochemical experiments are used to study reaction and condensation processes in cosmic clouds. Experiments on the catalytic formation of complex organic compounds observed in meteorites are also being carried out. Theoretical research examines the origin of comets and of interstellar molecules and relationships between them. Ground based observations of comets are continuing as is the application of image intensifiers to such faint diffuse light sources. IUE observations of comets and interstellar molecules are being up-dated. Accumulation of photographic material for the part 2 of the Atlas of Cometary Forms will be resumed.

**W77-70595** **188-45-51**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**COMET AND ASTEROIDS**
D. P. Burcham 213-354-3028

This RTOP contains two tasks aimed at understanding asteroids, their origins, compositions and relationships to other planets and satellites. (1) physical properties: This task is an extension of our previous observational and theoretical studies of compositions, albedos and histories of comets and asteroids. We plan to accelerate our survey of asteroids at mid infrared wavelengths (1.65 and 2.2 micrometers) as our first efforts have confirmed the great value of these observations to compositional classification (see Johnson et al., 1975). (2) origin of asteroids and small bodies: Studies of meteorites show that they are samples of a variety of bodies ranging from very primitive compositions which have never been heated to strongly modified bodies which have melted. No particular meteorite class can yet be said to come from a particular body but in recent years asteroids which appear similar to meteorite classes have been found and dynamical transport mechanisms for getting asteroid collision debris into earth crossing orbits have been developed. One of these mechanisms, using secular resonances, has been developed under this study and it is proposed to continue this investigation. The continued study of asteroid families, which are the collision fragments of asteroids, is also proposed.

**W77-70596** **188-45-53**
Ames Research Center, Moffett Field, Calif.
**COLLECTION AND ANALYSIS OF COMETARY AND METEOR DEBRIS FROM THE ATMOSPHERE**

D. R. Chapman 415-965-5065
(176-10-11; 195-21-04)

The objective is to compare the properties (elemental and mineralogical) of material collected in the atmosphere after a meteor fireball event with the debris ablated from meteorites, and the cosmic dust background level in the stratosphere. The particulate collections will be obtained using basic instruments currently available and on board the U-2 aircraft supporting Ames stratospheric research program (RTOP 176-10-11). The collection will be attempted on meteor fireballs with magnitudes of approximately -10 or greater within 30 hours of the event (to ensure largest possible particles will be collected) at an altitude of approximately 20 km. The flightpath will be determined using ground observation data and a meteor fireball wake distribution pattern based upon known stratospheric wind conditions employing a classical atmospheric fallout model. The analyses to be performed on collected specimens will include optical mineralogy, petrography, density, X-ray diffraction, electron microprobe, scanning electron microscope, laser microprobe, and ion microprobe. These results will be compared with current data describing physical properties of aerosols in the stratosphere and those characteristics of meteor ablation debris obtained from studies on meteorite fusion crusts and results obtained during artificial meteor ablation experiments.

**W77-70597** **188-45-53**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**COSMIC DUST RESEARCH**
D. P. Burcham 213-354-3028

The objective of this task is the development of a spectrometer capable of determining the mass and energy distributions of ions in a rapidly moving plasma. No such spectrometer now exists. Two important uses for a flight instrument with the planned capability are (1) the determination of the composition and dynamics of charged particles in cometary comas and ion tails, and (2) the determination of mass and energy exchanges between the solar wind and any planetary atmosphere exposed to it. In both instances the proposed instrument could map the flow patterns of several species of newly ionized cometary or atmospheric gases and determine the resultant drag or perturbation of the solar wind. During FY-76 we are testing a new design concept which greatly increases the angular acceptance and sensitivity of the spectrometer. Objectives for the TR and FY-77 are the completion of the optimization and design of the analyzer geometry, selection of detectors for use on a comet mission, analysis and design of a voltage generation and control system, design of a flight-type magnet, and calibration of the analyzer-detector system.

**W77-70598** **188-46-52**
Goddard Space Flight Center, Greenbelt, Md.
**THEORETICAL HIGH ENERGY ASTROPHYSICS**
E. Ramaty 301-982-4715

The objectives are (1) to conduct theoretical research in high energy astrophysics with particular emphasis on areas of interest to the general program of the Laboratory for High Energy Astrophsycis, (2) to provide support of graduate students from the University of Maryland to participate in research leading to doctoral dissertations in theoretical astrophysics, (3) to publish in the scientific literature the relevant and significant results obtained from research carried out by members of the group (4) to provide theoretical support for satellite experiments and mission definition studies, conducted both within and outside the Laboratory for High Energy Astrophysics. The theoretical group in the Laboratory for High Energy Astrophysics consists of two civil service employees R. Ramaty and L. A. Fisk, one National Academy Research Associate, B. Smith, 1975-76, and two graduate students T. Bai and R. Bussard. Members of the group have maintained a high level of theoretical expertise in high energy astrophysics and have attempted to contribute to and keep abreast with new developments in this area of astronomy. Using this expertise, they initiate and support theoretical research in the Laboratory for High Energy Astrophysics. They have also contributed to the weekly Goddard-University of Maryland Astrophysics Seminar both as lecturers and as advisors on topics and potential speakers.

**W77-70599** **188-46-56**
National Aeronautics and Space Administration, Washington, D.C.
**PARTICLE ASTROPHYSICS**
Albert G. Opp 202-755-8493
(188-46-57)

The objective of this RTOP is to study the isotopic and charge composition and energy of galactic and solar cosmic rays. The primary galactic radiation represents the direct penetration of material from the Galaxy into the solar system. The study of the nuclear composition and energy of this material provides direct evidence of the stellar processes responsible for the cosmic radiation and information on the interstellar material transited by the cosmic radiation. The observation of solar cosmic rays provides information on the abundances of different elements in the sun and information on the solar processes that accelerate energetic particles to their observed energies. The design, construction and test of cosmic ray detectors is the prime activity supported by this RTOP. Solid state detectors, magnetic spectrometers, scintillators, Cerenkov counters and ionization spectrometers are typical instruments developed and tested under the support of this RTOP. Research balloons are employed extensively. Balloon flights are used both to test instruments and to obtain new scientific information on the properties of cosmic radiation. New instrument concepts are also tested at particle accelerators.

**W77-70600** **188-46-56**
Goddard Space Flight Center, Greenbelt, Md.
**PARTICLE ASTROPHYSICS AND SHUTTLE EXPERIMENT DEFINITION**
F. B. McDonald 301-982-4801

The objectives are (1) to measure the energy spectra, charge and isotopic composition of the primary cosmic radiation and of solar cosmic rays and the distribution of cosmic rays in space. Supporting this objective is the development of new detector systems for the study of the properties of cosmic radiation, and the associated development of theoretical studies related to these experiments. The results will be used in astrophysical considerations concerning the origin, acceleration and propagation of cosmic radiation, and (2) to develop a variety of new detector systems for high energy astrophysics research, including cosmic-ray, X-ray and gamma ray astronomy. Meaningful new experiments in these fields presently require the development of several new devices, incorporating new improvements in energy, charge and isotope resolution, in temporal resolution and directional resolution, and utilizing very large payloads of great size and weight, capable of orbit with the shuttle. Detectors will be designed, constructed, and tested in our laboratories. Detector behavior will be explored using particle accelerator beams and other devices. Balloon flights will be carried out both for the purpose of detector development and for obtaining new scientific information. New measurements will be made of the properties of cosmic radiation available for study at balloon altitudes. Beyond 10 to the eleventh power eV, no information is presently available, because the spectra fall steeply with increasing energy requiring large area detectors and long exposure times. This large exposure must be obtained while maintaining the resolution of much smaller detectors. Energy measurements in this highly relativistic range are currently being done using ionization spectrometers and gas Cerenkov detectors. Development of new techniques such as transition radiation detectors and magnetic spectrometers, will be required for some measurements. These detectors are being developed for shuttle missions which will provide the essential exposure time and background free environment.

**W77-70601** **188-46-57**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GAMMA-RAY ASTRONOMY**
D. P. Burcham 213-354-3028

This describes the JPL program in X- and gamma-ray astronomy, part of which is a cooperative effort with UCSD. The primary objective of the program is to observe nuclear gamma-ray line spectra from extraterrestrial sources in the .02 to 10 MeV energy range. Such observations could provide important information on nucleosynthesis, galactic history and

the physical nature of various celestial objects including cosmic X-ray and gamma-ray sources, both constant and transient. Under this program, a high resolution gamma-ray spectrometer balloon system will be used in a series of astronomical observations. Additional activities will be the development of advanced concepts in detection techniques, instrumentation and data analysis. The specific objectives for this program for TR-77 and FY-77 are to reduce, analyze, and publish the data from previous balloon flights; conduct two observational balloon flights from Palestine, Texas; and continue the evaluation of a gamma-ray burst detector.

**W77-70602** **188-46-57**
Goddard Space Flight Center, Greenbelt, Md.
**GAMMA RAY ASTRONOMY**
C. E. Fichtel 301-982-6281

The technical objective is to develop the most appropriate detector systems for the observation of the astrophysical sources of very energetic photons. The approach has been divided into several different parts. The first approach to the general problem of gamma-ray astronomy was the development of a large telescope using digitized spark chamber to be tested on high-altitude balloons and then flown on satellites. Other approaches to detector systems are now being pursued both for the high-energy gamma rays, intermediate gamma ray studies, and low energy gamma ray observations. Detectors for low energy gamma ray astronomy are now being studied, particularly for gamma ray lines. A first generation medium-energy gamma ray detector was built and flown on a balloon, and a second generation experiment has now been designed. A unique feature of this system is its high time resolution which will permit the tagging of several gamma rays during a short (microseconds) pulse as might be excepted from a supernova outburst. Improvements in the track imaging chamber systems are continuing and special attention in the track imaging chamber research is now being directed at designing and building a low cost chamber of significantly larger size. At the same time, several approaches are being explored to improve angular resolution. A factor of two improvement in positional accuracy in both dimensions has already been achieved. Time-of-flight systems are being studied to improve the rejection rate of events which are not gamma rays. These developments should provide the improvements in sensitivity and angular accuracy which are critical to the future advancement of gamma ray astronomy, and at the same time reduce the cost.

**W77-70603** **188-46-57**
National Aeronautics and Space Administration, Washington, D.C.
**GAMMA RAY ASTRONOMY**
Albert G. Opp 202-755-8493
(188-46-59)

The objective of this RTOP is to measure the characteristics of energetic photon emission from celestial sources and to understand the physical processes responsible for the emissions. This RTOP includes photonic radiation from approximately 10 keV in energy upward to as high as can be measured, that is, from hard X-rays to ultrahigh energy gamma rays. Several sources have been identified, which have spectra extending into the hundreds of KeV or higher. The spectra of discrete sources and the spectra and distribution of the diffuse background will provide information on the physical processes active in stars, pulsars, galaxies and interstellar space. Gamma ray photons result from a number of physical processes (see Item 14). These processes can furnish information on the synthesis and distribution of elements in the universe, on the magnetoplasma environment of a star, on the condensation and interaction of interstellar material with radiation, as well as other astrophysically important parameters. Gamma rays, which are undeflected by magnetic fields, travel directly from their sources, and anisotropies in the direction of arrival of the photons gives information on the location of the gamma ray sources. Current results provide crucial data relating to the structure of our galaxy.

**W77-70604** **188-46-59**
National Aeronautics and Space Administration, Washington, D.C.
**X-RAY ASTRONOMY**
Albert G. Opp 202-755-8493
(188-46-56; 188-46-57)

The objective is to investigate and understand the nature of sources of X-ray emission. The number of such sources detected has been increasing by virtue of the active observational program being conducted with balloons, rockets, and satellites. As experimental techniques have been refined, a number of point sources have been identified with unusual optical objects both galactic and extragalactic in origin. In addition, X-ray variability of different characteristic forms has been found; some sources are analogous to the radio and optical pulsars. The general cosmic X-ray background, as well as the point sources need further study in order to elucidate the emission mechanism and the cosmological significance of these objects. Specific objectives are the detection of additional sources, spatial mapping of the background, accurate positional determination and correlation with optically identifiable objects. These objectives are met by supporting laboratory studies, flight programs, and theoretical work. Research and development of advanced detectors, shielding systems, and focussing optical systems are being conducted. Data processing methods are being refined.

**W77-70605** **188-46-59**
Goddard Space Flight Center, Greenbelt, Md.
**X-RAY ASTRONOMY**
E. A. Boldt 301-982-5853

Celestial X-ray sources have introduced us to rich new aspects of astronomy ranging from the millisecond bursts of hard X-rays coming from the innermost orbits of matter falling into a black-hole to the beamed emission of a pulsar exhibiting a highly cut-off spectrum characteristic of radiation from the magnetic poles of a neutron star with an inferred field of approximately 10 to the 13th power G. The combination of large sensitive area, low detector background, high temporal resolution and non-dispersive spectroscopy over a broad bandwidth has been our approach in discovering and exploring these phenomena. The power of this approach is being well demonstrated. Extending it with improved spectral resolution and broad-band imaging is a major area of development now indicated. This involves the creation and evaluation of new systems incorporating low noise ionization counters of optimum resolution, large area X-ray concentrators, imaging counters and associated scatter-hole camera configurations.

**W77-70606** **188-46-60**
Goddard Space Flight Center, Greenbelt, Md.
**DETECTOR AND SYSTEMS DEVELOPMENT FOR LOW ENERGY AND MEDIUM ENERGY ASTROPHYSICS (APPROXIMATELY .25 keV TO APPROXIMATELY 10 MeV)**
R. W. Hobbs 301-982-2591

The overall objectives of this project are the development of improved detectors and spectrometer systems to study the emission and absorption spectra of discrete and diffuse sources of astrophysical interest and the angular distribution of such sources. Spectral line and continuum measurements provide a rich source of physical information allowing the determination of parameters such as excitation temperature, ionization temperature, abundances, densities and Doppler shifts. High spectral resolution is required to detect spectrum lines and separate them from each other and from a continuum. Observational data in the 0.3 MeV to 90 MeV range may provide important cosmological information about the early history of our universe. Cosmic gamma rays in this energy region are expected to be highly isotropic and thus of cosmological origin. A direct observational test of the isotropy can thus be an extremely sensitive test of cosmological origin. The use of conical focussing crystal spectrometers provide extremely high spectral resolution, improved signal to background ratio, and one dimensional imaging. Such a system is particularly applicable to measurements in approximately .5 keV to 10 keV region. Charge coupled devices (CCD) promise high spectral and spatial resolution in the .25 to 10 keV region. Organic semi-conductor X-ray detectors appear to offer the possibility of high spectral resolution possibly without cooling. Shaped scintillation detectors on small satellites show great promise for measurement of differential

energy spectra and angular distribution with a better signal to noise and angular sensitivity than has been able to be accomplished up to now in the 100 keV to 10 MeV energy region.

**W77-70607** **188-78-51**
Marshall Space Flight Center, Huntsville, Ala.
**LOW GRAVITY SUPERFLUID HELIUM ADVANCED TECHNOLOGY DEVELOPMENT**
Richard A. Potter 205-453-3431

Several experiments are currently being developed which will require a low temperature environment for their proper operation in space. Superfluid helium will undoubtedly be used for many of these applications. Immediate application to experiments are to be found in cosmic ray, relativity and infrared astronomy. The purpose of this RTOP is to investigate theoretically and experimentally, where possible, the properties of superfluid helium to be expected when liquid helium dewars are flown into space. The properties of superfluid helium in this near zero gravity environment will be assessed and methods will be investigated whereby problem areas may be resolved and/or controlled. Low gravity aircraft and rocket flights will be conducted to permit more realistic design on helium dewars.

**W77-70608** **188-78-51**
Goddard Space Flight Center, Greenbelt, Md.
**ADVANCED TECHNOLOGICAL DEVELOPMENT, GENERAL: SIGNAL AND DATA PROCESSING ELECTRONICS; SOLID STATE DETECTORS**
James H. Trainor 301-982-6282

The technical objectives of this research project are to develop and test new onboard signal handling, data processing, storage, computing and auxiliary electronics circuitry for use in energetic particle and astrophysics experiments on spacecraft, rockets, balloons, etc., as well as special test and analysis equipment applicable also for both ground and shuttle usage. The growing complexity of experiments and the often corresponding increase in the volume of data obtained have made signal handling, data processing and data transmission capability limiting factors. To reduce the transmission of unnecssary data, it is necessary to increase the experiment's on-board signal handling and data processing capability. This program is approached through (1) the investigation and development of new techniques for signal shaping and handling, data processing and auxiliary circuitry, and (2) the modification of existing techniques by the application of advanced technology and materials including MOS/LSI technology, thick film techniques, and multiple chip techniques. Special techniques must also be devised in order to accurately and efficiently evaluate and test the flight systems at low cost. The use of micron-processors and minicomputers is being pursued both for ground testing and in-flight data systems. The technical objective of the research project is to conduct a program of research and development, and device test and evaluation in the field of silicon and germanium nuclear radiation detectors with emphasis on (1) the improvement of detector technology; (2) the understanding of the radiation damage effects on device operation and lifetime; (3) the understanding of the effects on these detectors of chemicals commonly used near or on spacecraft; (4) to establish the technology for the fabrication of specialized devices not available from industry; and (5) to continue the pragmatic life testing now underway.

**W77-70609** **188-78-60**
Goddard Space Flight Center, Greenbelt, Md.
**ADVANCED MISSION STUDIES FOR ASTROPHYSICS EXPLORER PROGRAMS**
M. B. Weinreb 301-982-6849

The objective is to perform studies and necessary research in support of continuing advanced mission studies for Explorer class missions as defined in NASA AO#6 and AO#7. AO#6 solicits participation in the scientific teams that will define missions for Explorer spacecraft launched by either Scout or Delta vehicles or Space Shuttle. AO#7 solicits proposals for the complete definition of individual scientific missions for Explorer class spacecraft launched by Scout only. The approach is to support assigned studies and tasks related to the above AO's involving NASA, the U.S. scientific community and the international scientific community. Support will be provided by conducting required study and research effort either in-house, out-of-house, or in combination. Support is being provided now in evaluation of available proposals. This will continue for future proposals. Assistance will be further provided in support of the scientific mission definition teams appointed as a result of the AO activities.

**W77-70610** **188-78-60**
Marshall Space Flight Center, Huntsville, Ala.
**HIGH ENERGY ASTROPHYSICS ADVANCED MISSIONS**
Joseph R. Dabbs 205-453-2817

Shuttle launched free flying spacecraft instrumented for High Energy Astrophysics are planned for the time period of 1980's onward. The Space Science Board (SSB) has given high priority to a 1.2m X-ray telescope, a cosmic ray and gamma ray free flyer and the large area moderate angular resolution (LAMAR) X-ray payload. Feasibility studies have demonstrated that all candidate missions studied may be flown using either the existing HEAO Spacecraft or the proposed Multi Mission Spacecraft, both requiring minor modifications. The candidate missions as supplied by the Physics and Astronomy Programs Office will be examined with regard to subsystem commonality and design feasibility of the overall flight observatory. This will include a detailed technical analysis of the science and spacecraft systems.

## Planetary Biology

**W77-70611** **192-55-61**
Ames Research Center, Moffett Field, Calif.
**CHEMICAL EVOLUTION**
H. P. Klein 415-965-5094
(192-55-66; 192-55-67)

The objective is to understand the origins and chemical evolutionary pathways of organic matter in the cosmos which led, in the case of the Earth, to the emergence of life but which, in extraterrestrial environments, may have taken divergent paths. Approach-Chemical evolution research encompasses the study of the evolutionary path of carbon and its compounds from the primal fireball, through interstellar clouds, to formation of solar systems, to the beginnings of life on Earth. In laboratory experiments conducted under conditions designed to simulate the putative environments of cooling solar nebulae and primitive and contemporary planetary atmospheres and surfaces, the extent and nature of abiotic synthesis of organic matter is determined. Natural evidence bearing on the validity and generality of the chemical evolution hypothesis and the diversity of its manifestations in the cosmos is sought through organic analysis of cosmological materials having extraterrestrial (e.g., meteorites, lunar samples, interstellar dust grains, martian soil) and ancient terrestrial origin. The study of contemporary environments and recent sediments and the laboratory simulation of geological environments is undertaken to provide knowledge of the ways in which organic matter in mineral matrices is transformed by the process of diagenesis over geological time spans.

**W77-70612** **192-55-61**
National Aeronautics and Space Administration, Washington, D.C.
**CHEMICAL EVOLUTION**
R. S. Young 202-755-3732
(192-55-62; 192-55-67)

The objective is to understand the prebiological chemistry which led, in the case of the earth, to the formation of organic compounds and the origin of life but which on extraterrestrial bodies may have taken divergent paths. Chemical evolution encompasses the study of the evolutionary path of carbon and its compounds from the primal fireball, through interstellar dust clouds to formation of galaxies, solar systems, and planets, to the beginnings of life on the earth. In the laboratory, the syntheses of organic compounds related to terrestrial biochemicals are explored in experiments which simulate the putative environments of interstellar dust clouds, cooling solar nebulae, and planetary atmospheres and surfaces. This research will provide an

experimental basis to evaluate the hypothetical sequence of events beginning with the synthesis of organic compounds from simple components in the atmosphere of the primitive earth and ending with the origin of life.

**W77-70613** **192-55-62**
National Aeronautics and Space Administration, Washington, D.C.
**ORGANIC GEOCHEMISTRY**
R. S. Young 202-755-3732
(192-55-61)

Organic geochemistry is the study of ancient terrestrial rocks for organic molecules and inclusions of biological origin. The objectives of this RTOP are: (1) the development of techniques for the isolation of organic matter and distinguishing organic matter of biological origin from that of non-biological origin, and (2) the applications of such technology to returned extraterrestrial samples.

**W77-70614** **192-55-63**
National Aeronautics and Space Administration, Washington, D.C.
**PLANETARY SOIL MICROBIOLOGY**
R. S. Young 202-755-3732

The objective is to develop techniques for the detection and characterization of life and the-related molecules. There are a variety of techniques which can be used to determine the presence or absence of life in a given sample of soil on the earth. These techniques have application to extraterrestrial environments as well. The purpose of this RTOP is to determine which methods of detecting life or life-related organic chemicals have the highest probability of performing unambiguously either in situ on other planets or in a terrestrial laboratory.

**W77-70615** **192-55-65**
Ames Research Center, Moffett Field, Calif.
**BIOINSTRUMENTATION**
H. P. Klein 415-965-5094

The objective is to develop instrumentation and techniques for the detection and characterization of life on other planets. The primary emphasis of the program is directed toward the planet Mars, but consideration will be given to application of the instrumentation to other planets. The work projects involve the continued development of the 'Unified Biology Experiment' and the 'Wet-Chemical Amino Acid Analyzer,' which are post-Viking experiment candidates. Development of operational breadboards and prototypes for the Unified Biology and the Wet Chemistry Analyzer experiments will be continued with emphasis on test programs to insure that the current designs will adequately perform the scientific goals of the experiments and to identify engineering problems which will require further design and development efforts.

**W77-70616** **192-55-65**
National Aeronautics and Space Administration, Washington, D.C.
**BIOINSTRUMENTATION**
R. S. Young 202-755-3732

The broad objective of the effort is to develop instrumentation and techniques for the detection and characterization of life on other planets. The primary emphasis of the program is directed at the exploration of Mars but consideration will be given to the application of instrumentation to other planets. Development of operational breadboard models and prototype hardware for the Unified Biology Experiment and Wet-Chemistry Amino Acid Analyzer will be continued. Emphasis is placed on test programs designed to: (1) assess the reliability of current experimental designs, (2) determine if the instruments can accomplish the scientific goals for which they were designed, and (3) identify engineering problems which require additional design and development efforts.

**W77-70617** **192-55-66**
Ames Research Center, Moffett Field, Calif.
**PLANETARY ENVIRONMENTS**
H. P. Klein 415-965-5098
(192-55-61; 192-55-67)

The objective is to provide specific compositional information on the terrestrial and outer planet atmospheres and surface matter to better construct pertinent models of planetary chemical evolution and status which is necessary for understanding the conditions that are necessary for the origins of life in our solar system and for establishing the probability of life in the universe. Methods and instruments are being developed for analyses of planetary atmospheres and surface materials from instrumented probes, penetrators, landers, flybys and orbiters as well as of samples returned from meteoritic and planetary sources. Concepts are being formulated and tested in the laboratory to (1) detect and measure candidate constituents for each of the prospective planetary atmospheres, (2) detect and measure microorganisms and biological activity in soils, and (3) detect and measure organic and biogenic substances in soils. Advanced plans are being formulated in which critical concepts will be tested for developing a containment facility for the analysis of returned planetary samples.

**W77-70618** **192-55-66**
National Aeronautics and Space Administration, Washington, D.C.
**PLANETARY ENVIRONMENTS**
R. S. Young 202-755-3732

Analytical methods will be developed for the determination of biologically important planetary environmental characteristics such as composition of the atmosphere, presence or history of water and occurrence of organic emissions. The methods and instruments so developed for planetary exploration will be useful in assessing a planet's ability to sustain a biota.

**W77-70619** **192-55-67**
Ames Research Center, Moffett Field, Calif.
**ORIGIN AND EVOLUTION OF LIFE**
H. P. Klein 415-965-5094
(192-55-61; 192-55-66)

The objective is to advance our understanding of the processes, mechanisms, environmental conditions and time-frames involved in the origin and evolution of life on Earth. To apply this knowledge to the development of models of the possible origin of life on other planets, to assessments of the likelihood of contamination of other planets by terrestrial organisms, and to the evaluation and analysis of returned planetary samples. The approach is to evaluate the physical and chemical parameters constraining life; to ascertain and understand the mechanisms used by organisms in approaching those constraints; to investigate the evolution and regulation of such adaptive mechanisms; to identify the role played by selected environmental factors in the sequence of biological evolution; to study the interactions and energetics of molecules which may have been involved in the origin of life; and to examine possible developmental sequences of the mechanisms capable of providing energy for living systems.

**W77-70620** **192-55-67**
National Aeronautics and Space Administration, Washington, D.C.
**ORIGIN OF LIFE**
R. S. Young 202-755-3732
(192-55-64; 192-55-61)

The objectives are to understand the sequence of events and the mechanism(s) by which the first living systems originated from a complex milieu of organic molecules on the primitive earth, and to apply this knowledge to assess the likelihood of such events occurring now or in the past on other planets. Studies on the origin of life focus on the interactions of complex organic molecules that may have been present during the later stages of chemical evolution on the primitive earth, their organization into systems with one or more characteristics of living cells, and their eventual evolution into metabolizing, self-replicative systems. Research is pursued which investigates the origin of the genetic code, protein synthesis, cell membranes, and important metabolic processes involved with energy capture and utilization. Life appeared on earth some 3.5 billion years ago as a result of largely unknown processes. It is known that organic compounds are made when the gases assumed to be

present in the primitive atmosphere are subjected to various forms of energy.

## Planetary Quarantine

**W77-70621** **193-58-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PLANETARY QUARANTINE ADVANCED STUDIES**
C. W. Craven 213-354-5322

Planning and analytical studies will be carried out which support the development of planetary quarantine requirements together with basic analytical techniques for their effective implementation in flight programs. Potential contaminating events of future missions will be evaluated. Specifically, these studies will include: (1) evaluation of the impact of planetary quarantine constraints on Jupiter-Uranus flyby missions, as well as probe missions to the outer planets; and (2) determining the effects of the natural space environment on the survival of microorganisms. These studies are conducted to identify and better understand the planetary quarantine constraints applicable to various planned missions. This, in turn, will permit the development of procedures and methodology to reliably satisfy such constraints. This RTOP also provides for Planetary Quarantine Project Office functions (as directed by the NASA Headquarters Program Office). These include program planning, definition of resource requirements, technical monitoring of research work, solicitation and evaluation of technical proposals, and establishment of research contracts. In addition, a JPL detailee, located at NASA Headquarters, is provided to support the Planetary Quarantine Program Office on a day-to-day basis and to provide support in budget and funding analyses.

## Lunar Science

**W77-70622** **195-20-01**
National Aeronautics and Space Administration, Washington, D.C.
**EARTH-BASED OBSERVATIONS**
E. A. Flinn 202-755-3730
(195-20-02; 195-20-03; 195-20-04; 195-20-05; 195-20-06)

The objective is to continue study of the lunar surface using earth-based instruments. Studies of broadband reflection spectroscopy is used to determine the chemical and mineralogical composition of the lunar surface. Another objective is the study of the moon in terms of composition, surface processes, and regional geology using data from telescopic spectral reflectivity. Using telescopic measurements of minute color differences, studies will be on separating lunar maria into chemical and stratigraphic units and dating these units.

**W77-70623** **195-20-02**
National Aeronautics and Space Administration, Washington, D.C.
**THEORETICAL STUDIES**
E. A. Flinn 202-755-3730
(195-20-01; 195-20-03; 195-20-04; 195-20-05; 195-20-06)

The development of scientific concepts about the composition, structure, stratigraphy, origin, and history of the moon and its constituent features reguires an iterative process of data acquisition, synthesis, and theory. The evolving theoretical models of the moon have been constantly refined through testing and modification in this series of studies. Major areas of research include temperature-pressures studies, cosmogenesis, seismology, electrical conductivity, geologic mapping, interactive of lunar materials with energetic particles, and thermodynamics of lunar processes.

**W77-70624** **195-20-03**
National Aeronautics and Space Administration, Washington, D.C.
**LABORATORY SIMULATION**
E. A. Flinn 202-755-3730
(195-20-01; 195-20-02; 195-20-04; 195-20-05; 195-20-06)

The objective is to study the moon by experimentation in the laboratory. This includes study of the lunar surface by laboratory observations and the effect of various types of solar radiation of silicate glass, study through models, the lunar interior structure and evolution as constrained by the physical and chemical properties of the same minerals found on the moon, study the shock effects in the laboratory of rock-forming minerals and the synthetic materials under a wide range of temperatures and pressures, and study shock metamorphism effects and cratering phenomena using the laboratory facilities.

**W77-70625** **195-20-04**
National Aeronautics and Space Administration, Washington, D.C
**ORIGIN AND COMPOSITION OF METEORITES**
B. M. French 202-755-3760
(195-20-07)

The objective of this program is to increase our knowledge about the nature, composition, age, origin, and history of meteorites by means of direct analysis of meteorite specimens and by related theoretical and observational studies. A wide variety of analytical techniques are used to obtain information about meteorite mineralogy, chemical compositions, radiometric ages, cosmic-ray-exposure ages, isotopic compositions, particle track characteristics, etc. This knowledge will improve our understanding of the physical and chemical processes present during information of the solar system, the nature and history of cosmic radiation in interplanetary space (use of meteorites as 'space probes'), and the genetic relations between meteorites and asteroid families. This research also supports ongoing lunar sample studies by providing important comparative data and by testing and calibrating new analytical techniques.

**W77-70626** **195-20-05**
National Aeronautics and Space Administration, Washington, D.C.
**ANALOG STUDIES**
E. A. Flinn 202-755-3730
(195-20-01; 195-20-02; 195-20-03; 195-20-04; 195-20-06)

Studies of terrestrial features that have been formed by similar processes to those that are believed to have shaped the moon's surface provide the data needed to interpret lunar history. The type of features being extensively studied are: terrestrial meteorite impact structures, terrestrial volcanoes, mass waste erosion, lava ridges, ash flows, and ejecta flows. These are the type of features that appear to be dominant on the lunar surface.

**W77-70627** **195-20-06**
National Aeronautics and Space Administration, Washington, D.C.
**SCIENCE EXPERIMENT CONCEPTS**
E. A. Flinn 202-755-3730
(195-20-01; 195-20-02; 195-20-03; 195-20-04; 195-20-05)

Experimental concepts are conceived, developed, and demonstrated that pertain to the lunar orbit and surface which require perfection of techniques of data reduction and analysis, and interpretation as well as investigation of concepts, instruments, and hardware including testing and calibration. These experiments emphasize geophysics and geochemistry.

**W77-70628** **195-20-07**
National Aeronautics and Space Administration, Washington, D.C.
**METEORS AND EXTRATERRESTRIAL DUST**
B. M. French 202-755-3760

The objective of this program is to obtain information about the nature, chemical composition, and distribution of small solid particles in interplanetary space by collecting and/or analyzing such material during entry into the earth's atmosphere. A variety of techniques are used, e.g., airborne particle collection, and spectral analysis of meteor trails. A major aim is to develop criteria for analyzing microparticles and for distinguishing

extraterrestrial microparticles from natural and artificial contaminants.

**W77-70629** **195-21-02**
Ames Research Center, Moffett Field, Calif.
**THEORETICAL STUDIES OF THE MOON AND METEORITE PARENT BODIES**
D. R. Chapman 415-965-5065

The objective of this research is to understand the origin, evolution, structure, and present state of the moon by means of theoretical investigations which incorporate the results of lunar, spacecraft, and groundbased experiments. Theoretical and experimental knowledge of physical processes are used, together with astronomical and geological data, to construct and analyze mathematical models of lunar processes and structure. The results of these calculations are interpreted in terms of such topics as: thermal state, composition, electrical conductivity, material properties, and evolution of the moon; the effects of solid convection in the lunar interior on the present thermal state of the moon and the distribution of radioactive heat sources within the moon; and the interpretation of rare gas studies of meteorites and lunar samples.

**W77-70630** **195-21-03**
Ames Research Center, Moffett Field, Calif.
**IMPACT CRATERING EXPERIMENTAL STUDIES**
D. R. Chapman 415-965-5065
(383-21-02)

The objective is to study scaling laws and trajectories of debris ejected from impact craters formed in various targets to understand impact crater formation and emplacement of crater deposits on various planetary surfaces and to study the formation of doublet craters and their ejecta patterns. The Ames vertical gun impact range will be used. Gravitative effects are evaluated by cratering 'dropping' noncohesive sand targets where each drop has a selected constant acceleration and where the cratering is recorded on 35 mm stereo movie film. Multi-colored patterned sand targets are used to establish points of origin and deposition of ejecta. A plate dissector is used with a high speed camera to record trajectories and velocities of fragments ejected throughout crater growth. Special layered targets are impacted to study the origin of lunar and terrestrial impact melts, and techniques of achieving simultaneous impact developed earlier are used to model conditions of origin of selected lunar crater complexes suspected of having such an origin.

**W77-70631** **195-21-04**
Ames Research Center, Moffett Field, Calif.
**CHEMICAL AND ISOTOPIC STUDIES OF METEORITES AND ABLATION PRODUCTS**
D. R. Chapman 415-965-5065

The objective is to characterize formation and post-formational histories of carbonaceous chondrites and basaltic achondrites, and integrate results with IR spectra of planetary surfaces and of circumstellar dust for modeling studies, and (2) determine mineralogical and chemical fractionation occurring in material produced by artificial meteor ablation to characterize those products entering the Earth's atmosphere so that new criteria can be developed for identifying debris ablated from meteors and comets. This will permit determination of the origin of the debris. On (1), electron microprobe, laser microprobe and ion microprobe studies of carbonaceous chondrites and basaltic achondrites will be carried out to obtain data that will augment that obtained previously to permit refinement and testing of models of their formation. Additionally, a program of aircraft measurement of IR system of planetary surface and of circumstellar dust will be evaluated to determine its utility in obtaining additional data necessary to expand models of meteorite origins. In (2), a carbonaceous chondrite sample will be ablated in the Ames supersonic arc jet to characterize its ablation debris. These results, together with results of previous study, will be used to identify extraterrestrial particles collected from the stratosphere using U-2 aircraft.

**W77-70632** **195-22-02**
Goddard Space Flight Center, Greenbelt, Md.
**THEORETICAL STUDIES**
J. A. O'Keefe 301-982-4445

Critical studies are made on problems of planetology. This field has grown very rapidly in the past 10 years; some generally accepted doctrines in the field have never been scientifically demonstrated. Among these are the proposition that: (1) the planets formed by accretion (some may have been formed by fission), (2) most craters on planets other than the earth were impact-produced (they may be volcanic), (3) mare-like areas (presumably lava flows) are filling basins formed by impact, (the mare lavas themselves may have depressed these areas.) and (4) homogeneous glasses can be produced by meteorite impact on a planetary surface, (this is irreconcilable with the principles of glassmaking.) Included in this field are studies of planetary volcanic processes, planetary fission, planetary isostatic response mechanisms, and the application of glass technology to the formation of natural glasses. Special emphasis is placed on problems related to the origin of the planets. This effort will be stopped at the end of FY -77.

**W77-70633** **195-22-03**
Goddard Space Flight Center, Greenbelt, Md.
**PHYSICAL AND CHEMICAL STUDIES OF SOLAR SYSTEM SOLIDS**
P. Wasilewski 301-982-4317

The characterization of the phase reactions and associated magnetic properties in materials which simulate meteorites and planetary surface materials and which are affected by shock impact and thermal processes in variable FO2 conditions, will be done and will be related to integrated synthesis and interpretations of available meteorite and planetary surface data in order to develop process-response models to provide a basis for understanding planetary magnetism. Laboratory experiments utilizing man-made alloys and other simulations which have been subjected to known dynamic and thermal histories will be conducted concurrently with experiments on meteoritic material whose history must be deciphered. The manner in which dynamic and thermal processes affect spectral reflectance will be recorded as part of the systematic program in order to relate magnetism to telescope reflectivity curves and other remote sensing techniques. Newly defined and established remanence acquisition by controlled, dynamic and thermal processes as a function of field dependence will be explained. The objectives of the research program are to study induced and modified remanent magnetization due to shock impact in materials which simulate condensed matter in our solar system and to calibrate iron which in our proposed experiments will become ferromagnetic over the temperature range 77 K - 1043K, a consequence of shock impact, vapor deposition, growth from the vapor etc. The initial emphasis of our continuing research will be directed toward a more complete understanding of the following: (1) remanence induced in the direction of the shock wave normal by impact in zero field, (2) uniaxial magnetic anisotropy induced by shock impact, (3) the superparamagnetic to single domain transition due to shock impact induced shape change of small particles, (4) dependence of magnetic stability on peak pressure.

**W77-70634** **195-22-04**
Goddard Space Flight Center, Greenbelt, Md.
**GEOCHEMISTRY OF EXTRATERRESTRIAL MATERIALS**
J. A. Philpotts 301-982-5206
(195-22-03; 195-22-06)

The objective is to conclude a study of some aspects of the nature and evolution of condensed matter in the solar system. Laboratory determinations will be made of major and trace element abundances, mineralogy and petrology, and isotopic compositions. Meteorites will be the prime samples studied.

**W77-70635** **195-22-05**
Goddard Space Flight Center, Greenbelt, Md.
**TERRESTRIAL ANALOGUE STUDY OF METEORITE IMPACT CRATERS**
J. A. Philpotts 301-982-5206
(195-22-03; 195-22-04)

The objective is to understand the effects of the meteorite impact process through study of the nature of terrestrial impact

craters. Particular attention will be paid to the systematics of the radiometric dating techniques K-Ar and Rb-Sr, including the conditions under which partial or total resetting of apparent ages occurs. Compositional and other affects will also be studied. Terrestrial impactites and unshocked country rocks will be the prime samples studied.

**W77-70636** **195-22-06**
Goddard Space Flight Center, Greenbelt, Md.
**SYSTEM AND RADIATION EFFECTS STUDIES FOR ORBITAL X-RAY AND GAMMA RAY SPECTROMETER**
J. I. Trombka 301-982-5941

The over-all objectives are the development of X-ray and gamma-ray spectrometers for remote sensing systems to be included aboard lunar and planetary missions. A number of areas are under study; redesign of the X-ray detector collimator to give a more symmetric response as compared with the Apollo system; development of a new calibration source in terms of the variation of the solar spectrum, the continued study of on-board data processors, the further development of near real-time data processing systems, and finally the study of the cosmic ray induced activity in X-ray and gamma-ray detectors, specifically intrinsic Ge. We also plan further development of the electron spectrometer for lunar related research. Problems in solar wind darkening are of specific interests. Included with the Apollo X-ray spectrometer experiment was a solar monitor to be used to calibrate the spectrum for spectral changes in the sun's emission. This system did not turn out to be too satisfactory. We therefore plan to study an alternate method which utilizes measurement taken with a method depending on the monitoring of the X-ray fluorescence produced in a known composition slab. The slab would be placed so that it would receive direct solar irradiation and the emission would be monitored with a detector similar to that used in measuring the X-ray flux from the planetary surface. The multiplex data accumulator (MDA) now operating in our laboratory would be used to simulate previous on-board data processing systems in order to study optimum design for various on-board data processing systems in order to determine optimum design for various remote sensing systems. Furthermore earth-based data processing systems will be tied in with the on-board system to simulate total mission processing.

**W77-70637** **195-23-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**EARTH BASED LUNAR OBSERVATIONS**
D. P. Burcham 213-354-3028

The scientific objectives of the proposed work are threefold: (1) assess the global (front side) uniformity of heat flow rate, (2) assess the global uniformity of several thermophysical and electrical properties of the lunar regolith, and (3) reconcile the current best-estimates of regolith properties with new measurements of the shape of the brightness temperature lunation curve at several wavelengths. Regional anomalies of heat flow will be investigated by constructing maps at 21 cm and 3.5 cm and comparing contours of the lunation-averaged temperature. Significant differences in the maps can be interpreted as heat flow anomalies. Regolith property anomalies will be investigated by comparing both lunation curves and mean temperatures from high resolution maps at several wavelengths between wavelength 13 cm and 3 mm. The explanation of lunation shapes in terms of regolith properties will entail low resolution approximately 6' arc) observations at wavelength 3.5 to 13 cm and the use of a comprehensive microwave moon model.

**W77-70638** **195-23-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**THEORETICAL STUDIES**
D. P. Burcham 213-354-3028

Electron spin resonance (ESR) studies will be carried out on lunar, meteoritic and terrestrial samples with objectives as follows: (1) to determine the nature and origin of paramagnetic species Fe30(+), Ti30(+), Mn20(+) and radiation damage centers (trapped electrons and holes) in very fine grains of lunar surface material, and to establish their relationship to the evolution of the lunar regolith and those of meteorite parent bodies; (2) to fully characterize paramagnetic and radiation damage centers in a series of C-1, C-2, and C-3 carbonaceous meteorites in order to understand the initial planetary process and the magnetic and radiation environment in which planetary bodies (including the moon) formed; and 3) to upgrade the present ESR system with the addition of a high-field magnet in order to provide a better characterization of multidomain meteoritic magnetic and lunar metallic Fe phases and thus permit their use as ferromagnetic resonance geothermometers for probing the thermal and annealing history of extra-terrestrial samples. We have used the second derivative ESR method to successfully detect paramagnetic species and radiation damage centers at the ppm level in carbonaceous meteorites and in lunar regolith materials. This improved method which obviates the interference of ferromagnetic resonances due to magnetite and metallic Fe now permits ESR methodology to be used as a sensitive, general, nondestructive method for examining the thermal, radiation and geologic history of these extraterrestrial materials as recorded in the ferromagnetic and paramagnetic centers. This will help us to understand both those processes which led to the formation of the planets and those involved in the early history of the moon and its regolith evolution.

**W77-70639** **195-23-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**LABORATORY SIMULATION**
D. P. Burcham 213-354-3028

The purpose of this study is to (1) compare the surface properties of solar system objects of lunar size, and (2) compare the processes (including interactions with the space environment) which affect the properties. The objective is to decipher the history of formation of the bodies and development of their surfaces as represented by their surface chemical and mineralogical composition. The approach will be to develop the necessary laboratory data that can be used to better interpret astronomical observations of those solar objects that are similar in size to the moon or smaller. The moon serves as an important bench-mark for comparison because the techniques available for studying the surface properties of objects have been developed largely through remote astronomical studies of the moon followed by in situ verification by Surveyor and Apollo missions. The proposed studies include: (1) a laboratory study of the spectral reflectance and luminescence properties of candidate rock and mineral phases for the surfaces of outer planet satellites with emphasis on evaporites and other volatile-rich phases; (2) laboratory studies of the affects of profon irradiation and impact vitrification on the optical and chemical properties of evaporite and volatile-rich phases; and (3) comparison of the surface evolutionary histories of various satellites as evidenced by interpretation of optical telescopic data of these bodies.

**W77-70640** **195-23-06**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ADVANCED EXPERIMENT CONCEPTS**
D. P. Burcham 213-354-3028

The objective of this program is to undertake scientific studies and long lead-time engineering development in anticipation of an opportunity to chemically map the entire lunar surface from a spacecraft placed in a close lunar polar orbit. Reference points include the results of the Apollo 15 and 16 gamma ray experiment, the scientific potential and design requirements of a high purity Ge detector gamma-ray spectrometer that can be used at other planetary bodies in addition to the moon.

## Planetary Astronomy

**W77-70641** **196-41-50**
Goddard Space Flight Center, Greenbelt, Md.
**GROUND-BASED INFRARED ASTRONOMY**
V. G. Kunde 301-982-5693

Ground-based measurements of Venus have been obtained with a Michelson interferometer in the 400-500cm(-1) and 750-1200cm(-1) regions with a spectral resolution of 0.2cm(-1). Evident in the spectra are numerous CO2 molecular absorption

lines and several diffuse absorption features in the 850-1200cm (-1) region. Preliminary interpretation of the diffuse features from the observed continuum, using homogeneous model atmospheres, and considering only absorption, strongly indicates a 75% solution of H2SO4 for the composition of the clouds of Venus. The scientific objective of this research is to develop a more complete understanding of the physics of the Venusian atmosphere in the region above 200mb. This will be accomplished by developing a more physically realistic radiative-transfer model for line formation including scattering in an inhomogeneous model atmosphere. With this model additional information may be derived from the observed spectra concerning the physical parameters of the cloud particles and the cloud stratification.

**W77-70642** **196-41-51**
Goddard Space Flight Center, Greenbelt, Md.
**RADIO AND RADAR PLANETARY STUDIES**
J. K. Alexander 301-982-5461

The objective of this program is to obtain information on the nature, extent, and dynamical behavior of planetary magnetic fields, trapped radiation belts, and magnetospheres by studying the nonthermal radio emissions from the planets. The major approaches to this investigation are (1) synoptic observations of Jupiter's decametric radiation via a global network of monitoring instruments and (2) theoretical analyses of the generation and propagation of nonthermal radiation in a planetary magnetosphere. The Jupiter Monitor Network is providing unique data relative to the rate and stability of the magnetic field rotation and the physics of satellite-plasma interactions in the magnetosphere, and correlative data for fly-by in-situ measurements. Analysis of the radio measurements in the context of new information from the Pioneer 10 and 11 Jupiter encounters may lead to a clearer understanding of the radio emissions and their role in particle-field interactions in the magnetosphere.

**W77-70643** **196-41-52**
Goddard Space Flight Center, Greenbelt, Md.
**IMAGING STUDIES OF COMETS**
J. C. Brandt 301-982-4701

This RTOP provides for the operation of a small high altitude observatory for imaging research on comets and their interactions with solar radiation and solar wind. In addition, if a suitably bright comet appears, radio observations will be made with existing national facilities.

**W77-70644** **196-41-54**
Goddard Space Flight Center, Greenbelt, Md.
**ADVANCED INFRARED ASTRONOMY AND LABORATORY ASTROPHYSICS**
Michael J. Mumma 301-982-6994

The advanced infrared astronomy program purposes to study the molecular constituents of solar system objects (e.g. planetary atmospheres and comets) through observations of their IR/MM line spectra, in order to extend our knowledge about: (1) molecular abundances, (2) kinetic, vibrational, and rotational temperature distributions, (3) vertical and spatial distributions, and (4) ambient gas densities, and to execute comparative studies of these objects. The physical information we seek is contained in the intensity profiles of isolated spectral lines and can be obtained by inversion of the observed line shapes. The measurement of spectral line shapes has recently become a tractable problem at IR wavelengths, and line shapes can now be measured by infrared heterodyne spectroscopy and by mm-wave coherent spectroscopy. The approach is to develop and employ coherent detection line receivers for use in the infrared and millimeter wavelength regions. The infrared front end has been built for use with gas lasers or semi-conductor diode lasers as local oscillators and HgCdTe photo-mixers, while the mm-wave front end features Klystron local oscillators and Schottky diode mixers. Both feed into a GSFC standard spectral line receiver which analyzes, displays, and outputs the spectral lines. Initial observations with these systems has been from the ground but both systems have been developed with an eye toward flight on the NASA C-141 and in space. Laboratory work on precise frequency determinations and on pressure broadening effects is also carried out in support of the field experiment (see also RTOP 188-41-52-06).

**W77-70645** **196-41-67**
Ames Research Center, Moffett Field, Calif.
**PLANETARY ASTRONOMY AND SUPPORTING LABORATORY RESEARCH**
D. R. Chapman 415-965-5065

The abundance, temperature, and pressure of certain constituents of planetary atmospheres can be determined by spectroscopic observations from ground-based and from airborne observatories. Such data is required for the preparation of model atmospheres needed to evaluate the possibilities of life on the planets and to design systems for exploratory missions. The objectives of this work are (1) to study airborne and ground-based observations of planetary spectra, (2) to obtain in the laboratory the spectroscopic parameters needed to analyze the observatory spectra, and (3) to develop the analytical and computational techniques to interpret the spectra in terms of real planetary atmospheres. Spectroscopic parameters, such as absorption line and band intensities and absorption line half-widths, as well as data regarding their dependence on pressure and temperature, will be obtained for molecules of planetary interest by using long path gas cells, cooled and heated gas cells, and high resolution spectrometers and interferometers operating primarily in the infrared. Aircraft spectra of the planets and their satellites will be obtained and analyzed to secure information about the composition and structure of their atmospheres and the composition of their surfaces.

**W77-70646** **196-41-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**GROUND-BASED INFRARED ASTRONOMY**
D. P. Burcham 213-354-3028

The purpose of this effort is to obtain and analyze high-resolution near-infrared (1-6 microns) spectra of the planets in direct support of ongoing and planned planetary missions. The principal equipment employed is the Mk III Connes'-type Fourier spectrometer at the 2.7 m telescope, McDonald Observatory; ancillary approaches such as laboratory infrared spectroscopy, theoretical radiative transfer, model atmospheres and spectrum synthesis are also applied. We also undertake the development of new instrumentation to enhance capabilities for this work. To this end, a conceptual design study for a new, very high resolution Fourier spectrometer for use with the new Mauna Kea infrared telescope has been completed. We are also in the process of modifying the McDonald Interferometer to permit faster operation and the acquisition of spatially-resolved planetary spectra.

**W77-70647** **196-41-73**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**RADIO AND RADAR PLANETARY STUDIES**
D. P. Burcham 213-354-3028

The ongoing objective of the Radio Astronomy effort is to conduct comprehensive studies of the atmospheres, magnetospheres, and surfaces of planets and their satellites. Theoretical models are constructed; radio astronomical observations are made to test the models and to provide input for theoretical refinements. Primary interest is currently focused on Venus, Mercury, and the four major planets and their satellites. The observational experiments are conducted at JPL's Table Mountain Observatory (TMO), the Deep Space Network Tracking Stations, Caltech's Owens Valley Radio Observatory (OVRO) and other observatories as required by specific needs of the program. Research programs at these facilities are planned in order to take full advantage of the unique capabilities of the individual systems, especially the new 36 GHz interferometer at TMO and the 64-m antenna and advanced low-noise receivers at the DSN stations. The immediate objective of the Radar Astronomy task is to obtain radar data on the planets for determining properties of their surfaces, orbits and spins, with Venus, Mercury, Mars, Saturn's rings and Jovian Satellites as prime subjects. This work employs the unique facilities of the DSIF and exploits synthetic aperture techniques. The Microwave Radiometer development effort supports the Radio Astronomy task. The goal is to design, construct, and maintain advanced microwave radiometer systems and associated digital

systems for use at the Table Mountain, Goldstone, Owens Valley and other radiotelescope facilities that are used by the group.

**W77-70648** **196-41-74**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SUPPORTING LABORATORY STUDIES**
D. P. Eurcham 213-354-3028

The objective of the proposed task is to provide image processing support to Dr. Michael Belton of KPNO in his analysis of spectroscopic and imaging data of Uranus. This is a continuation and an expansion of an unfunded investigation conducted during FY-76. During the preliminary investigation automated techniques were developed for scanning and digitizing spectroscopic data, correlating the spectra as a function of Uranus radius, and thus determining the apparent inclination of the spectral lines. These techniques were applied to a limited amount of data supplied by Dr. Belton. The results obtained were very promising, and Dr. Belton has requested that these techniques be applied to new spectroscopic data which he has obtained using the 2.1 m Coude feed and the 4 m telescope at KPNO. He has also requested that some of the image processing techniques developed for, and applied to the Mariner 10 data of Venus be applied to a series of recent images of Uranus obtained by the planetary group at New Mexico State University. It is the objective of the proposed task to supply that support. The spectroscopic data and the New Mexico State pictures will be scanned and digitized at KPNO. The resulting digital tapes will be transmitted to JPL. The facilities of the Image Processing Laboratories at JPL will be utilized to perform the data processing. The results will then be transmitted to Dr. Belton for analysis and interpretation. The effort at KPNO will be funded by KPNO.

**W77-70649** **196-41-80**
National Aeronautics and Space Administration, Washington, D.C.
**GROUND-BASED OPTICAL PLANETARY ASTRONOMY**
William E. Brunk 202-755-3660

This investigation will attempt to extend our knowledge of the planets, their satellites, asteroids, and comets through the use of astronomical observations made with telescopes and other optical instruments located at ground-based observatories. The observations will be made throughout the visible and infrared portions of the spectrum. Reduction, interpretation, analysis, and publication of the data thus obtained will be included in this objective. The interest, experience and facilities of scientists outside NASA will be utilized to obtain data needed to support and supplement the planetary flight program. This investigation includes observations from ground-based observatories, as well as associated theoretical studies of the planets, their satellites, asteroids, and comets in the optical and infrared portions of the spectrum. The results of these studies are published in the open literature. The planetary science expertise and observational facilities required for this program are, in general, not available within the NASA centers. During Fiscal Year 1976, over 40 individual observational programs were carried out under 24 tasks involving 15 separate universities and other institutions. The program is designed to extend our understanding of the planets through support of outstanding planetary astronomers.

**W77-70650** **196-41-81**
National Aeronautics and Space Administration, Washington, D.C.
**ASTRONOMICAL OPTICAL INSTRUMENT DEVELOPMENT**
W. E. Brunk 202-755-3660

The objective is to design, develop, and construct auxiliary instrumentation to be used for ground-based astronomical observations. The auxiliary instrumentation includes such items as cameras, photometers, spectrometers, interferometers, etc. The scientific return that can be obtained under RTOP 196-41-80 is limited by the instrumentation available to the investigators. The actual level of scientific return possible from ground-based observations in the optical and infrared could be much higher if additional auxiliary instrumentation were available. Such instrumentation is developed under this task when the magnitude of the development is too great to be considered as part of the research task. Recently, tasks generally included under this RTOP are for the following: (1) design, development, construction, and testing of auxiliary instrumentation involving new observational concepts such as the recent development of a near IR imaging spectrometer; (2) construction of proven types of auxiliary instrumentation, such as very high resolution interferometers, so that they are available for use at different observatories.

**W77-70651** **196-41-82**
National Aeronautics and Space Administration, Washington, D.C.
**GROUND-BASED RADIO AND RADAR PLANETARY ASTRONOMY**
William E. Brunk 202-755-3660

The objective is to determine planetary properties by observations from ground-based observatories at radio wavelengths. Both passive (radio) and active (radar) observations will be performed. The program will include the reduction, analysis, and interpretation of the observations. The interest, experience, and facilities of scientists outside NASA will be utilized to obtain data needed to support and supplement the planetary flight program. This investigation includes observations from ground-based observatories, as well as associated theoretical studies of the planets, their satellites, and other members of the solar system in the radio portion of the spectrum. Both passive, radio astronomy, and active, radar astronomy, observing techniques are to be employed. The results of these research programs are published in the open literature. The planetary science expertise and observational facilities used in this program complement those available within the NASA centers and the Jet Propulsion Laboratory. During FY-1976, a large number of observational programs were carried out under 7 tasks (5 radio and 2 radar) involving 6 institutions. The program is designed to extend our understanding of the planets through the support of outstanding radio and radar astronomers.

**W77-70652** **196-41-84**
National Aeronautics and Space Administration, Washington, D.C.
**LABORATORY SUPPORTING STUDIES (ASTRONOMY)**
William E. Brunk 202-755-3660

The objective is to obtain laboratory data required for the analysis and interpretation of planetary observations made from the vicinity of the earth. The data obtained will be of two types: (1) detailed study of gases and other materials known to exist on a planet, and (2) study of the properties of many possible materials to try to explain unidentified features detected in planetary observations. The data obtained under this program will be published as well as being used directly in the interpretation of new observations. Principal investigators on tasks under RTOP 196-41-80 frequently find that there is insufficient laboratory data on the spectra of the molecular constituents they are observing. Needed is data for specific molecules at conditions and wavelengths not normally encountered in laboratory studies. It is therefore necessary to obtain this data using specialized very long path absorption cells at a range of temperatures and pressures. Tasks under this RTOP support such programs at non-NASA institutions. The technical plan is to determine laboratory values of the properties of materials known or suspected to be observed on the planets.

**W77-70653** **196-41-85**
National Aeronautics and Space Administration, Washington, D.C.
**THEORETICAL PLANETARY ASTRONOMY**
William E. Brunk 202-755-3660

The objective is to provide theoretical support for the planetary astronomy program by predicting what data should be observed and by explaining the observational results. The program also involves the integration of observational and laboratory results from many sources to provide an explanation of planetary phenomena. Based on prior knowledge of the planets and existing physical laws, programs are undertaken to predict the observational data on the planets. For example, theoretical atmospheric spectra are generated using assumed knowledge of the planetary atmospheric constituents, the spectral effects produced by a scattering atmosphere containing aerosols, and the dispersion of

the observable spectra. Comparison of the observed spectra with the theoretically calculated spectra tests the assumptions used in theoretical calculations. On the other hand, theoretical programs are also undertaken in an attempt to understand unpredicted observational results such as the radio noise storms observed at long radio wavelengths from Jupiter.

## Upper Atmospheric Research

**W77-70654** **198-10-04**
Ames Research Center, Moffett Field, Calif.
**AIRBORNE INSTRUMENT SYSTEMS FOR MEASURING TRACE GAS CONSTITUENTS IN THE STRATOSPHERE**
D. R. Chapman 415-965-5065
(176-10-11)

The goal of this project is the development and flight testing of airborne instrument systems for measurement of important gas species in the stratosphere. Several multiple species instrument systems for making accurate measurements of the minor gas constituents in the stratosphere are being developed for integration onboard aircraft and balloon platforms. The ability to make coordinated simultaneous measurements on a routine basis is being emphasized. Techniques such as chemiluminescence and IR spectroscopy are being employed.

**W77-70655** **198-10-06**
Ames Research Center, Moffett Field, Calif.
**DEVELOPMENT OF NEW INSTRUMENT SYSTEMS FOR DETECTION OF TRACE CONSTITUENTS OF THE STRATOSPHERE**
D. R. Chapman 415-965-5065
(176-10-11)

The objective of this plan is to develop new airborne instrumentation to measure the trace gas constituents in the stratosphere. This includes performing applied research necessary to develop fundamental principles and sensor techniques to a level of feasibility for making routine in-flight measurements. A study of many new techniques for measuring the trace gas constituents in the stratosphere has been in progress for several years. This study has yielded promising results for several species such as the halocarbons, methane, chlorine compounds, and hydroxyl radicals. Airborne systems based on these techniques are being developed for in situ measurements.

**W77-70656** **198-10-06**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**STRATOSPHERIC RESEARCH, FIELD MEASUREMENTS PROGRAM**
D. P. Burcham 213-354-3028
(176-20-51; 176-10-51)

The Field Measurements program is one of the two major parts of the JPL Stratospheric Research program. In pursuing its objective, it will rely heavily on the Laboratory Measurements program, which constitutes the second major part of the overall task. The objective of the atmospheric (field) measurements is the acquisition of data relevant to the three-dimensional distribution and temporal variability of stratospheric trace species. The data is acquired by the use of various remote sensing spectroscopic and radiometric techniques, at infrared, submillimeter, and microwave frequencies. The long-term measurement program exploits continued improvements in the detection and measurement capabilities of the techniques provided by the instrument development activities of other related tasks. Three distinct methods are employed: high resolution spectroscopy at near and middle-infrared wavelengths (Fourier spectrometers), laser heterodyne radiometry in the mid-infrared, and microwave and submillimeter radiometry. The latter two methods measure individual specific trace species, whereas the first provides spectral data over a wide frequency range covering a large number of gases in one observation. The measurements are made from a wide variety of high altitude aircraft and balloons, and from locations within the continental United States and in the southern hemisphere. The particular molecular investigations are chosen to exploit the specific advantages of individual techniques and equipment. However, more than one experimental technique will be used to obtain the required data for species of recognized importance to the NASA Stratospheric program (e.g. ClO). The locations and timing for the planned observations are chosen to optimize as far as possible the ability to derive the seasonal, diurnal and spatial variability of the species.

**W77-70657** **198-10-06**
Lewis Research Center, Cleveland, Ohio.
**GLOBAL ATMOSPHERIC SAMPLING PROGRAM (GASP)**
R. A. Rudey 216-294-6160

The concentrations of various particulate and gaseous pollutants in the region of the atmosphere between 20,000 and 45,000 feet are being measured by employing sampling devices on 747 commercial air transports. These measurements will be used to establish baseline data on the contaminants in the atmosphere in order to deduce the contribution of jet aircraft and other anthropogenic sources to upper atmospheric pollution; basic studies will be conducted to understand better the factors involved in the dispersion of jet engine pollutants. This information may then be used to determine the necessary steps required to reduce pollution by jet aircraft. Pollutant components to be measured include carbon monoxide, oxides of nitrogen, ozone, water vapor, chlorofluorocarbons (CFM's), condensation nuclei, total particulate count, and anions collected on filter samplers.

**W77-70658** **198-10-06**
Lyndon B. Johnson Space Center, Houston, Tex.
**STRATOSPHERIC TRACE GAS MEASUREMENTS**
A. E. Potter 713-483-2576
(198-10-10)

The resonance fluorescence technique shall be used to develop systems to measure altitude/density profiles of certain atmospheric trace constituents. Resonance tubes or lasers will be employed to excite atmospheric species and to detect the resonance fluorescence from these species. The system shall identify the species and quantify its density: It shall be packaged as a remotely operated payload for balloon, rocket and aircraft flights. Single and multiple species instruments will be developed for OH, NO, Cl and ClO. An instrument developed by the Environmental Effects Project Office and the University of Pittsburgh will be further expanded and used to provide in-situ measurements of atomic oxygen. An in-house modified Dasibi will be used for ozone support to the flights. The same basic resonance fluorescence techniques will be further expanded to include H2O, NO2, ClO2, BrO, HO2 by using atomic oxygen addition and the OH measurement extended down to the troposphere. When more flight support systems are available a cluster of four instruments can be flown together to measure O, H2O, HO2, NO, NO2, Cl, ClO, ClO2, BrO. Several combinations of these and ultimately all of them can be flown simultaneously. In addition to these measurements a set of whole air samples will be provided by the University of Michigan and added to the flight package to provide a measurement of CH4, N2O, H2, and chlorofluorocarbons

**W77-70659** **198-10-07**
Lyndon B. Johnson Space Center, Houston, Tex.
**FILTER COLLECTION SYSTEM STRATOSPHERIC MEASUREMENT OF HCL AND HNO3**
D. E. Robbins 713-483-6121

The objective is to develop an experiment to measure stratospheric HCl and HNO3 compatible with the JSC Stratospheric Balloon Payload and to make simultaneous measurements with other species which are chemically linked with HCl and HNO3 in the stratosphere. An air filtration sampler technique utilized successfully by NCAR will be redesigned to allow samples to be taken in the stratosphere on the JSC Stratospheric Balloon Payload. Work is required on the filter sample changer and the air intake system to allow samples to be made at a faster rate. The technique uses filter paper to collect air samples which are analyzed by 'wet chemistry' procedures in the laboratory.

**W77-70660** **198-10-10**
Ames Research Center, Moffett Field, Calif.
**AIRBORNE PLATFORM DEVELOPMENT AND SUPPORT**

**FOR STRATOSPHERIC SAMPLING PROGRAM**
D. R. Chapman 415-965-5065
(198-10-04; 198-10-06)

Task I is to provide CV-990 aircraft support to the Lewis Research Center Global Air Sampling Program (GASP). Task II is to evaluate the capability and operational suitability of new types of airborne platforms for carrying in situ or remote sensing instrumentation into the stratosphere. LeRC experimental equipment (operational & prototype) will be flown on the CV-990 (NASA 712) for development testing of prototype equipment and for obtaining atmosphere constituent data in 'off-normal-airways' areas. A flight evaluation program will be carried out to determine the capability and operational suitability of a fighter-type aircraft (F-4/F-15) for carrying in situ stratospheric sampling instrumentation to altitudes of 30 km by a zoom-climb maneuver. Flying will be done at Edwards Air Force Base/Dryden Flight Research Center. Continuing surveying (and deployment to remote sites) will be recommended if the evaluation program indicates that the aircraft is capable of providing vertical profiles of important stratospheric chemical species.

**W77-70661** **198-10-10**
Lyndon B. Johnson Space Center, Houston, Tex.
**BALLOON MEASURING PLATFORM SUPPORT**
A. E. Potter 713-483-2576
(198-10-06)

Balloon systems will be utilized to measure stratospheric constituents involved in ozone chemistry. Species linked by rapid chemical reaction schemes will be measured simultaneously, within the same air volume. (See RTOP 198-10-06) This will eliminate uncertainties which are introduced into model verifications by single species measurements because of natural variations of the species in space and time. Data will be used to test the chemical schemes assumed in stratospheric models. Instruments utilizing the resonance fluorescence techniques are being developed under the Environmental Effects Project and will be used to measure certain of the stratospheric species of interest. These resonance fluorescence instruments will be used for O, OH, HO2, Cl, ClO, and NO, NO2 and BrO. A modified Dasibi instrument will be used to measure O3. These scientific instruments require flight systems support (i.e., electrical power, data handling, commands, mechanical interface, etc.). These requirements are satisfied by the integration of all the support systems and an NCAR telemetry system with a multi-module flight support platform. This flight support platform is provided to NCAR for balloon launch operations. Combinations of resonance fluorescence and other instruments will be integrated with a common balloon platform to allow simultaneous measurements of chemically linked species throughout the stratosphere to an altitude of 50 km. There will be twelve (12) multi-module flights from Palestine, TX through FY-78; two (2) flights from the Canal Zone; and two (2) flights from Alaska in FY-78 with the University of Michigan/resonance fluorescence instrument. In addition two (2) flights from Palestine, TX of the GSFC/photo ionization mass spectrometer will be supported in FY-77 and FY-78.

**W77-70662** **198-20-02**
Lewis Research Center, Cleveland, Ohio.
**SCAR STRATOSPHERIC EMISSIONS IMPACT**
S. Gordon 216-433-4000

The objective is to evaluate and develop techniques to analyze and describe the possible detrimental effects of man-made pollutants on the natural stratosphere. These pollutants include the exhaust emissions from supersonic aircraft as well as other pollutants, which rise into the stratosphere from ground level, such as chlorofluoromethanes. The approach is to formulate a model of the interaction between pollutants and the ozone from chemical kinetic principles and to verify the model by comparing computations with measurements in an atmospheric simulation chamber.

**W77-70663** **198-20-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**LABORATORY MEASUREMENTS/STRATOSPHERIC RESEARCH**
D. P. Burcham 213-354-3028

A program of laboratory studies related to stratospheric research will be conducted in the following areas: (1) kinetics and photochemistry, (2) infrared laboratory spectroscopy, (3) laser laboratory spectroscopy, (4) analysis of atmospheric reaction schemes, (5) atmospheric diffusion studies, and (6) laboratory measurements of ionic processes. The Program will be designed to provide data needs and guidance for both chemical models and field measurements. Primary emphasis will be on the acquisition of kinetic data including reaction rate constants, temperature dependence, and product formation. Photochemical quantum yields, absorption cross sections, and product distributions will be measured. Laboratory spectral measurements will be conducted to support the JPL infrared and laser field measurement activities. Atmospheric reaction schemes will be examined both experimentally and analytically for possible errors or omissions. Studies of atmosperic diffusion processes will purpose to understand the mechanisms of mass transport within the stratosphere. Ionic processes important to the mesosphere will be studied by the technique of ion cyclotron resonance. A broad base of data knowledge in all the foregoing areas will be maintained through literature surveys and through contact with other groups active in these areas.

**W77-70664** **198-20-03**
Lyndon B. Johnson Space Center, Houston, Tex.
**LABORATORY EXPERIMENTS PHOTOCHEMISTRY CROSS SECTION MEASUREMENTS**
D. E. Robbins 713-483-6121

This experiment aims to determine the photoabsorption properties of atmospheric halocarbons and their contributions as a source of stratospheric halogen atoms due to photolysis. Existing 1-meter and 3-meter spectrometers at JSC will be used to measure photoabsorption cross sections of halocarbon gases of importance to stratospheric ozone chemistry. These measurements will cover the wavelength range in the ultraviolet from about 1750A to about 2700A.

**W77-70665** **198-20-03**
Ames Research Center, Moffett Field, Calif.
**STRATOSPHERIC RESEARCH - LABORATORY STUDIES**
D. R. Chapman 415-965-5065
(198-30-02)

Studies of the composition, photochemistry, structure and dynamics of the Earth's stratosphere require extensive support by investigations of molecular, radiative and chemical properties of selected species in the laboratory or by advanced theoretical methods. Some of the required research must be performed by use of unique NASA laboratory facilities while some are best performed in collaboration with University researchers through grants or contracts. Molecular properties (radiative and spectroscopic constants) of selected stratospheric species of photochemical importance will be measured in long path absorption cells or in reaction chambers and shock tubes. University grants and contracts have been let for investigations of spectroscopic constants of stratospheric chlorine bearing species in support of remote measuring investigations. Band system identification, absorption strengths and line half-width measurements of species capable of being measured by infrared remote sensing instrumentation will be performed in Ames' long path absorption cell facility. A collaborative experimental and theoretical study of aerosol properties and the role they play in stratospheric chemistry will be performed by university grant.

**W77-70666** **198-30-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**INTERNATIONAL CONFERENCE ON THE STRATOSPHERE AND RELATED PROBLEMS**
D. P. Burcham 213-354-3028

The objective of this RTOP is to provide for a conference entitled 'International Conference on the Stratosphere and Related Problems' to be held in Logan, Utah (Utah State University) on 15, 16, 17 September 1976. The goal of the conference is to provide a focus for establishing the needs and directions for future research by bringing together the international community involved in stratospheric research and in investigations related to stratospheric problems. In particular the requirements for a

NASA research program on stratospheric problems recently directed by Congress will be formulated.

**W77-70667** **198-30-02**
Ames Research Center, Moffett Field, Calif.
**STRATOSPHERIC RESEARCH**
D. R. Chapman 415-965-5065
(176-10-11; 198-20-03)

The objectives of this investigation are to understand the composition, structure, and dynamics of the earth's stratosphere and mesosphere, and the important chemical and physical processes which occur there. Collaboration with the academic community will be fostered to advance new model development. Several types of chemical and dynamic models of the stratosphere have been developed to provide improved descriptions of the complex processes which occur in the upper atmosphere. These models contain varying degrees of complexity with respect to chemistry and atmospheric motions. The powerful computational techniques available in the Illiac IV at Ames will be applied to these models. Collaboration with scientists in the academic community is continuing and efforts to expand collaborative activities are underway.

**W77-70668** **198-30-02**
Langley Research Center, Langley Station, Va.
**STRATOSPHERIC STUDIES PROGRAM**
P. F. Holloway 804-827-2893
(176-40-31)

The objectives of this RTOP are: (1) to conduct theoretical studies of the interactive processes which affect stratospheric dynamics, chemistry, and thermal balance; (2) to conduct integrated studies necessary to the definition of a stratospheric measurement and monitoring strategy; (3) to conduct coupled assessments of stratospheric effects due to atmospheric injection of chlorofluoromethanes and nitrogen oxides; and (4) to conduct studies supporting the assessment of Space Shuttle stratospheric effects. The approach followed will be to use existing analytical techniques and apply them to determine the importance of key areas of uncertainty, such as the natural variability of the stratospheric chemical and dynamic cycles and the interactive relationships that exist between radiative transfer, photochemistry, and dynamics. The analytical models will be used in conjunction with ongoing work related to the development of a satellite sampling strategy and the statistical analysis of existing ozone data. Coupled stratospheric models will be applied to the assessment of the effects of antropogenic activities on the ozone shield and on the earth's thermal balance.

## Life Sciences

**W77-70669** **199-01-01**
Ames Research Center, Moffett Field, Calif.
**CARDIOVASCULAR DECONDITIONING**
E. P. McCutcheon 415-965-5741

The program's purpose is to provide solutions to the problem of cardiovascular deconditioning produced by weightlessness. Within this purpose, the objectives are to (1) determine the fundamental cardiovascular changes associated with space flight; (2) develop safety monitoring criteria and techniques, emphasizing detection and evaluation of latent disease states; and (3) provide protection for susceptible individuals by preventing or counteracting adverse effects. Both human and animal studies, with development of advanced bioinstrumentation and Space Shuttle-Spacelab experiments, apply to each objective. (1) Fundamental Mechanisms will document the effects of deconditioning on regulatory (homeostatic ) processes using provocative orthostatic stresses such as centrifugation and altered external pressure. (2) Safety Monitoring will develop predictive indices for deconditioning susceptibility, including detection of latent disease and its effects on tolerance. (3) Protection will test procedures, devices and drugs preventing and counteracting deconditioning. Results include: (1) the mechanisms of cardiovascular deconditioning will be better understood, (2) monitoring devices for critical variables will be provided with guidelines for safety decisions before, during and after flight, and (3) devices and procedures to modify deconditioning effects will be made available. Impact will be greatly improved flight safety, a broader segment of the population will have access to flight, and the weightless environment will be used to expand understanding of cardiovascular function.

**W77-70670** **199-03-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**CREW AND PASSENGER MEDICAL SELECTION CRITERIA**
W. Hoffler 713-483-4461

The objectives are: (1) to determine relevant and current (continually updated) medical criteria for selection of optimally capable and effective crew and passengers who will fly the Space Shuttle; (2) to implement a functional plan utilizing these criteria in flight medical operations for medical evaluation of astronaut candidates, for periodic medical evaluation of astronauts, and for intermediate and final phases of medical evaluations of passenger candidates; and (3) to establish a base of clinical space flight medical data as a reference resource to assure timely and effective inputs into operational space flight, both in terms of routine health maintenance and of long-term prevention of illness, for the preservation of maximally useful space flying careers, and assurance of successful space missions. The current developments emphasize tests, standards, and criteria for screening, selecting, and training pilots and passengers for 7 - 30 day missions. Directed toward safety and efficiency, criteria must necessarily apply for large populations in terms of age range, sex, background and nationality. On the one hand sufficient specificity of criteria to assure safe and successful completion of missions is mandatory, while on the other, oversensitivity of criteria must not preclude the flying of well trained and qualified passengers. These efforts will result in documentation of required standards, an implementation plan, and interactive techniques for selection from potential candidates the optimal team for a given mission. This approach will insure selection of crew and passengers able to withstand the stresses of the Shuttle.

**W77-70671** **199-05-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**SPACE MOTION SICKNESS**
J. L. Homick 713-483-4731

Manned space flight to date has demonstrated that space motion sickness (O-g sickness) can be unpredictable and variable among individuals. A significant observation is that in individuals who do experience this problem, symptoms can persist through the third, fourth, or even fifth day of flight. Thus, on short duration Shuttle flights, a major portion of mission time could be spent with crewmen who are not operating at maximum efficiency. The research program outlined by this RTOP is directed specifically toward resolving the problem of space motion sickness. An integrated program of basic and applied research on humans and animals will be conducted with four major objectives or end-products in view. These are: (1) a complete understanding of the causes of this syndrome in O-g; (2) criteria for accurately identifying, prior to space flight, individuals susceptible to the problem; (3) satisfactory methods for the prevention of the problem and (4) effective methods for the treatment of symptoms when they occur. The overall objective of this research program is to produce the information required to solve the problem of space motion sickness and neurosensory adaptation to the weightless environment. A broad based program of interrelated studies will be undertaken to delineate the etiology of the space motion sickness syndrome and to develop effective measures for its prediction, prevention, and treatment. Specific attention will be directed toward investigations of vestibular, proprioceptive, and visual function and their various---

**W77-70672** **199-07-01**
Ames Research Center, Moffett Field, Calif.
**BONE/MUSCLE ALTERATIONS**
D. R. Young 415-965-5549

Losses in bone mineral, muscle mass, and muscle strength have been observed in crew members exposed to weightless space flight. The losses have not been of clinical concern, but

the basis for the alterations has not been explained adequately and the consequences for passengers and crew members in future long duration space flight have not been assessed. The goals of this RTOP are to provide the ground-based program and implement the future flight experiment program required to clarify the mechanisms producing musculo-skeletal alterations during space flight, to determine remedial countermeasures for the prevention of alterations, and to provide operational guidelines for crew safety. Solution of the musculo-skeletal problem area will be based upon recognition of operant physiologic mechanisms as they are altered by space flight, the extent and manner in which those changes could impair tolerance for long duration space flight, and the development of techniques for minimizing potential physiologic limitations. Animal models and human volunteers will be studied under hypodynamic and hypergravic conditions. Improved methods for the assessment of bone/muscle alterations will be established. Countermeasures will focus upon skeletal loading and pharmacologic intervention studies. Flight experiment programs will be identified.

**W77-70673** **199-11-01**
Ames Research Center, Moffett Field, Calif.
**PREFLIGHT DETECTION OF DISEASE**
A. D. Mandel 415-965-5061

During the Apollo and Skylab programs a number of in-flight infections, including upper respiratory infections, viral gastroenteritis, skin infections of microbial and fungal origin have occurred. In addition there were several other in-flight disease events in which the clinical symptoms were highly suggestive of upper respiratory infections. During one of the Skylab missions, two crew members who were pre-flight carriers of Staphylococcus aureus, subsequently developed in-flight illness caused by these organisms. The objectives of this program are to develop measures for the rapid pre-flight detection of infectious disease, and procedures which will minimize the probability of an in-flight infectious disease event. Current laboratory diagnostic procedures for the identification of infectious agents will be studied in order to develop modifications which will decrease the time interval between sampling and identification of the infectious agent. Recent information that metabolic changes precede an infectious illness will be examined for its applicability to the early pre-flight detection of disease. As an aid to preflight disease detection the application of instrumentation to the antigen-antibody reaction will be investigated. The preflight disease detection methods will be verified by clinical studies and a program will be developed to apply these findings to eliminate or minimize the probability of inflight infections.

**W77-70674** **199-13-01**
Ames Research Center, Moffett Field, Calif.
**FLUID AND ELECTROLYTE CHANGES**
Carolyn S. Leach 713-483-5458

Body fluid compartment shifts occur in early exposure to weightlessness. These changes are complicated by losses in electrolytes (sodium, potassium, calcium, phosphorus, magnesium and chloride) occurring at a slowed rate over mission duration which further influence fluid distribution. Hormonal responses are elicited to counteract these changes. The purpose of this program will be to study the effect of these changes on man's (astronaut and non-astronaut) ability to function in space. Results of the investigations in this RTOP will provide an understanding of the physiological and biochemical effects of weightlessness and rationale for nutritional and/or other countermeasures for use in future space flight missions. The information gained from exposure to man to weightless flight for periods approaching 3 months has shown that fluid and electrolyte metabolism has been altered in all crewmen studied. It is apparent that the changes experienced are multiphasic and are caused not only by the weightless environment but also by conditions related to the preparation for flight, the activity during flight and the recovery procedures. The overall objective of this research program is the elucidation and definition of biochemical agents and physical factors operative in the processes associated with fluid and electrolyte metabolism in the space flight environment.

**W77-70675** **199-15-01**
Ames Research Center, Moffett Field, Calif.
**THE MONITORING AND MAINTENANCE OF CREW HEALTH**
John A. Rummel

This RTOP addresses the monitoring and maintenance of health of Shuttle crewmen. Health is defined as the 'state of the organism when it functions optimally without evidence of disease or abnormality.' Health, therefore, implies not only the absence of disease, but a positive concept in which normality has quantitative and definable boundaries. The objectives of this RTOP are to: (1) define health in relation to the space environment, (2) develop the procedures necessary to monitor health, (3) determine and develop appropriate countermeasures to maintain health, and (4) develop flight experiments to support above objectives. The end products will be: (1) a set of criteria which describe health within the context of normal adaptive responses to weightlessness, (2) a set of procedures and hardware which will permit ground-based personnel to detect changes which violate the criteria established in (1), (3) procedures and/or equipment necessary to counteract changes caused by weightlessness if these changes are considered detrimental to crew health, and (4) inflight potential experiments. A four-year program is defined together with appropriate reviews and checkpoints, and defining parallel as well as sequential activities. In-depth reviews are planned for current efforts to assure they support the basic problem addressed by this RTOP. Use of systems analysis is planned both for the direction and implementation of this RTOP.

**W77-70676** **199-17-01**
Ames Research Center, Moffett Field, Calif.
**HUMAN BEHAVIOR AND PERFORMANCE**
R. M. Patton 415-965-6602

Manned space missions require high levels of human performance in unfamiliar and stressful environments. Future missions will involve both crew members and scientist passengers, the latter chosen for their scientific and technical expertise, and not trained as career astronauts. Because of the high cost of these missions, and the high value of their successful completion, every effort must be made to maximize the probability of successful performance by all crew members and passengers. The objective is to develop selection, training, performance monitoring and corrective procedures that are appropriate to personnel on scientific space missions. Individual and group performance will be studied to determine what characteristics of behavior lead to effective performance and adjustment in simulations of space missions. Selection and training procedures will be developed to identify good candidates for space flight, and to train them in minimum time. Corrective procedures will be developed to deal with possible cases of performance breakdown in space. The product of this work will be a selection/training/monitoring system, suitable for validation in a full mission simulation.

**W77-70677** **199-19-01**
Ames Research Center, Moffett Field, Calif.
**DEFINITION OF PHYSIOLOGICAL DESIGN REQUIREMENTS**
J. M. Waligora 713-483-5156

The title of this RTOP, Physiological Design Requirements, implies quantifiable limits within which are assured some predictable levels of physiological performance. Such limits have been defined and used for each of our manned spacecraft programs but they have not been fixed. They have evolved from program to program and in all cases they have been referenced to assumed conditions as to the subject population, length of exposure, and a basic null hypothesis as to effects of zero-g. In the orbiter program and in manned programs that will follow from it, some of these assumed conditions will no longer apply. Defining and maintaining applicable Physiological Design Requirements will require research in several specific areas. (1) In the Shuttle era we will be dealing not with well conditioned relatively young pilots but with a broad population of men and women ranging in age to 65 years. An effort is required to define the response of this population. The vast majority of data collected on physiologic response to environmental stress has utilized young male college students and military recruits. (2) The physiologic

responses to space flight as demonstrated in Skylab and bed rest studies may have indirect effects on physiological response to environmental stresses. For example, the shift in body fluids in response to zero-g will require studies of the effect of this shift on tolerance to several environmental parameters.

**W77-70678** **199-21-01**
Ames Research Center, Moffett Field, Calif.
**SUPPORTING BIOMEDICAL RESEARCH**
J. Vernikos-Danellis 415-965-5747

The objective is to conduct ground based studies to determine the process, time course and consequences of prolonged stays in weightlessness. This research program will result in the identification of prolonged space flight problems, the selection and planning of flight experiments to confirm the existence and explain the mechanisms causing these problems and to indicate preventive or corrective means of ensuring the safety and tolerance of man in prolonged missions. The program will include both animal and human studies at the single cell as well as the whole body level. Skylab data and data from Kosmos flight experiments will be compared to those obtained from animals and humans in chronic stress situations and in weightlessness simulation (bed rest, inactivity) to determine the physiological cost of man's adaptation to prolonged space flight and the time course of such adaptation. Particular emphasis will be placed on mechanisms regulating hormone changes that accompany such general adaptation, on changes in gravity sensing tissue receptors in skin, muscle, tendons, heart, and on energy requirements during prolonged missions. Man's degree of adaptation will be measured by his ability to respond to unexpected demands such as infection, drugs and toxic materials, sleep deprivation, pain, heat, cold, and other emergencies such as tissue repair.

**W77-70679** **199-23-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**SUPPORTING BIOMEDICAL RESEARCH/JSC**
E. L. Michel 713-483-3518

The objective is to conduct biomedical research to insure man's well-being and his capability to function properly during extended space flight and upon subsequent reentry into the one-g environment. This research program together with planned flight experiments will identify potential problems, attempt to understand the causative mechanisms and provide solutions and/or appropriate countermeasures. This RTOP will collate those JSC research tasks which either do not specifically lend themselves to any of the problem-oriented RTOP's or conversely contribute and/or support many of these RTOP's.

**W77-70680** **199-25-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**CLINICAL USES OF SPACE AND CLINICAL APPLICATION OF SPACE TECHNOLOGY**
Paul X. Callahan 415-965-5755

Progress in clinical medicine during this century has been accomplished through a continuous process which includes clinical investigation, research, evaluation and application. The clinical investigation process has unraveled many of the basic mechanisms of disease. An understanding of the basic mechanisms of various diseases has frequently resulted in improved procedures for diagnosis and treatment. The clinical investigation process has often relied on the use of altered environments, for example, the use of cooling as part of the early treatment of burns or the use of hyperbaric pressure and an atmosphere enriched in O2 to treat osteomyelitis. The zero gravity environment of space flight may be useful as an environment for clinical investigation. Clinical and physiological measurements before, during and after manned space flight have demonstrated changes in man's biochemistry and physiology. Many of these changes can reasonably be attributed to weightlessness. Disease states are a complex interaction between host, disease entity and environment. It is reasonable to state that a change in the environment will, in many cases, affect the disease entity, the disease state, or the course of the disease either positively or negatively. The zero gravity environment offers a unique area in which to conduct clinical investigations including: diseases mechanisms research, diagnostic techniques development and therapeutic applications. The opportunities for clinical investigation in the zero gravity state are relevant at the component level (microbes and cells) as well as at the systems level (lower animals and man).

**W77-70681** **199-27-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**CLINICAL MEDICAL CREW SUPPORT**
S. L. Pool 713-483-4211

It is essential that future spaceflight passengers and crewmen be provided access to quality health care while in-flight. Clinical support systems have been used on all prior flights which involved man. Examples of the type of clinical support range from the rather limited Mercury, Gemini and Apollo medical kits to the Inflight Medical Support System developed for Skylab. The objective of this RTOP is to assure that adequate clinical support systems (hardware and software) are available for Shuttle passengers and crew. The approach may be separated into two major thrusts. One concerns the development of diagnostic systems, and the other concerns the development of therapeutic capability. The approach will be broad based and tie together several related efforts. It will involve a wide range of activities, from systems engineering and component production to evaluation and selection of equipment and medications.

**W77-70682** **199-41-01**
Ames Research Center, Moffett Field, Calif.
**SPACE BIOLOGY**
J. W. Tremor 415-965-6390

The objectives are: (1) explore and define responses in biological systems sensitive to the space environments; and (2) exploit the space environment to yield new information important to the understanding of how living systems operate. Since the weightless environment, of all the parameters peculiar to spaceflight, is most unique and only vanishingly duplicable on the ground, the major thrust of this RTOP will be directed toward understanding how organisms interact with this major force-gravity. Two types of studies are contemplated: (1) those necessary to help select biological systems or parameters that are most useful in studying or exploiting space effects, and (2) those designed to result in actual flight experiments. Other spaceflight factors will be studied, e.g., cosmic radiation effects as they interact with weightlessness. Research leading to the formulation of new hypotheses regarding gravity reception will be encouraged. Research at the cellular and lower organism levels, coupled with theoretical and experimental studies on possible molecular responses to gravity, will be supported with this end in view. Anticipating problems of human maintenance over long duration spaceflight, higher plant and animal studies will be encouraged: e.g., plants as they comprise components of life support systems, smaller vertebrates as they approach human analogues of systemic response to gravity. Genetic and developmental as well as regulatory responses to long-duration gravity alteration will constitute important elements of such research.

**W77-70683** **199-43-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**ECOLOGY/ENVIRONMENTAL EFFECTS**
D. S. Nachtwey 713-483-3419

The objective of this program is to investigate and define the extent of potential hazards to the biosphere posed by operations of Space Transportation Systems (STS) through the stratosphere. It has been postulated that emissions from Space Shuttle booster rockets may degrade the ozone layer and allow an increase in biologically damaging ultraviolet radiation (UV) to penetrate to the earth's surface. Factors other than Shuttle operations may also contribute to an increased UV via degradation of the ozone layer: high altitude aircraft emissions, halocarbon refrigerants or propellants from aerosol cans, nuclear weapons detonations, etc. Because of the multiple causes for potential ozone degradation and the various government agencies concerned, the study program represented here constitutes only a part of a more comprehensive study needed to provide definitive data on the total problem. The program presented here concentrates on those elements of the problem most relevant to NASA's need to assess the environmental impact of STS; studies germane to the effects of small increases in biologically

damaging UV on (1) human skin cancer incidence, (2) agricultural productivity, and (3) the stabilizing influence of natural terrestrial and aquatic ecosystems. The approach involves laboratory, field, and theoretical studies of certain harmful effects of enhanced solar UV-B radiation (285-320 nm) on experimental organisms and natural ecosystems.

**W77-70684** **199-45-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**RADIATION EFFECT AND PROTECTION**
D. E. Philpott 415-965-5218

The Radiation Effects and Protection RTOP is directed toward establishing a coordinated approach to identifying, quantifying, and counteracting the effects of exposure to the space radiation environment, both natural and man made. NASA is now embarking on a new era of space travel where crews and passengers will be exposed to the space environment for extended durations. Any space travel above very low earth orbits necessitates exposure of the personnel to potentially high radiation dose rates in the geomagnetically trapped radiation belts or, outside of the earth's magnetic field to the HZE particle flux (cosmic rays). Activities in space currently under consideration will necessitate exposure of space vehicles and crews to more intense regions of the geomagnetically trapped radiation belts or to large integrated fluences of HZE particles. The current consideration of large scale operations at geosynchronous altitude generates an urgent need for the knowledge and technology to be developed by this RTOP since the space radiation environment will be a major design driver for these activities. Geosynchronous operations incur the liability of lying in an intense region of the trapped radiation belts and also being subject to the unattenuated primary HZE particle flux. Quoting from the National Academy of Sciences report, HZE-Particle Effects in Manned Space Flight, 'We conclude that the HZE-particle question need not be considered a barrier to planning long-duration manned missions, but we recommend that a quantitative assessment of the potential hazard of these particles to man in space should be in hand.

**W77-70685** **199-51-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ADVANCED TELEOPERATOR TECHNOLOGY STUDIES**
E. Heer 213-354-3060

The objective is to develop technical information about Remotely Manned Systems (RMS) and teleoperators so that space missions requiring the use of such systems can be planned and implemented with the required reliability, performance, and economy. Specific objectives are to identify requirements, develop conceptual designs and breadboards, and determine the machine's and man's complementary roles in the operation of RMS and teleoperators including time delay requirements with emphasis on supervisory control. The approach is through technical studies identifying the scientific and operational mission requirements and by developing the resultant necessary RMS and teleoperator functions. From the implied capability requirements for man and machine, the necessary technology developments for teleoperator systems and subsystems are derived. Required developments are defined and implemented analytically and/or experimentally using simulation techniques, breadboard set-ups, or prototype equipment. These studies will give insight into the functions to be performed by man or machine or both for remote explorations and operations. Function allocations will be made between man and machine for various communication time delay requirements, so that optimum system performance can be achieved, and critical technology development requirements can be identified. New concepts of teleoperator systems and subsystems will be developed when appropriate and related feasibility studies will be conducted. Man-machine system performance evaluations will be conducted and performance criteria will be established.

**W77-70686** **199-53-01**
Lyndon B. Johnson Space Center,-Houston, Tex.
**MAN-MACHINE ENGINEERING REQUIREMENTS FOR DATA AND FUNCTIONAL INTERFACES**
Robert L. Bond 713-483-4966

The objectives are to move toward quantification of man-machine engineering data, both on the ground and in flight, to continue to pursue state-of-the-art technology and to advance that technology for the purpose of creating more effective and efficient man-machine interfaces for manned spacecraft, and to improve techniques of man-machine engineering design so that innovative steps may be taken toward creating better crew interfaces in future vehicles. The approach is to implement a series of continuing tasks to identify and implement workable instrumentation packages for acquiring quantitative man-machine engineering data in one-g, simulated zero-g, and actual zero-g, to continue those efforts currently defined that lead toward definitive design requirements inputs to and data outputs from the Design Performance Lab, and to pursue feasibility studies of promising new crew interface items.

**W77-70687** **199-71-01**
Ames Research Center, Moffett Field, Calif.
**ADVANCED EXTRAVEHICULAR SYSTEMS**
P. D. Quattrone 415-965-5733

The objective of this program is to advance the technology base for advanced EVA systems required to support long-term manned space missions. The advanced EVA systems must provide an extended EVA capability. The subsystem functions to be investigated and developed include greater suit mobility, minimal leakage, reduction of expendables, and increased thermal comfort. The emphasis of the advanced EVA equipment tasks will be placed on improving hardware performance, increasing system and hardware useful life, and reducing both payloads and EVA equipment design, manufacturing, maintenance and operation costs.

**W77-70688** **199-73-01**
Ames Research Center, Moffett Field, Calif.
**ADVANCED LIFE SUPPORT SYSTEMS**
P. D. Quattrone 415-965-5733

The objective of this program is to advance the technology base for regenerative life support systems required to support long-term manned space missions. The regenerative life support processes must provide a more complete system closure (reduction of expendables). The subsystems functions to be investigated and developed include the following: air revitalization; atmospheric supply and composition control; water reclamation; waste management; and advanced food technology. Specific life support subsystem technology areas will be investigated (feasibility and/or development), and subsystem concept designs will be generated. This RTOP will be directed toward advancing the technology and/or hardware development status for specific advanced life support subsystems, and will result in achieving a technology base (research and hardware development) for subsystems that have the characteristics of low maintenance, high reliability, and long life.

# OFFICE OF TRACKING AND DATA ACQUISITION

## Supporting Research and Technology

**W77-70689** **310-10-22**
Goddard Space Flight Center, Greenbelt, Md.
**MISSION SUPPORT COMPUTING SYSTEMS AND TECHNIQUES**
D. S. Woolston 301-982-5571
(310-10-26)

The objective of this RTOP is to ensure the availability of computing systems and techniques to meet the operational mission support requirements of imminent spacecraft missions. Major areas of emphasis are: (1) orbit determination and propagation; (2) generalized mission support for the shuttle era; and (3) tracking data processing and analysis. Research efforts are directed, for example, at analysis and feasibility studies of new techniques in orbit determination, including use of new data types; at defining and specifying flight dynamics support requirements in a multi-mission environment; and at optimizing tracking data utilization.

**W77-70690** **310-10-23**
Goddard Space Flight Center, Greenbelt, Md.
**SOFTWARE ENGINEERING FOR FLIGHT MECHANICS**
C. E. Velez 301-982-4725

The major objective of this work is the evolution of software development methodologies in the flight mechanics area. This will significantly reduce costs and enhance software quality and reliability. Many suggestions have been recently offered by computer scientists in the areas of software management, implementation and evaluation (eg. chief programmer teams, structured design and coding. higher order languages, etc.). It is generally recognized that the most effective software engineering techniques selected for use in operational systems will depend on the operating environment and characteristics of the problems to be solved (eg. onboard processing, near real-time operations, control computations, etc.). This work will therefore address the problem of evaluating software development methodologies in the following areas: (1) real-time on-board processing for attitude/orbit determination and control; (2) graphics aided near-real-time minicomputer processing of telemetry, tracking, and image data for navigation; (3) and batch processing. The approach will be to establish a 'software development laboratory' in which software engineering methods can be tested in a realistic environment. The laboratory will consist of a government furnished minicomputer facility supported by structured design and implementation software (eg. structured Fortran precompilers and other higher-order language processors) which will be used to implement applications software in the above areas cited. Based on criteria such as cost in man-hours, maintainability, reliability, minimum 'debugging' time, and operational simplicity, various approaches to software development will be evaluated. The ultimate objective of this project will be the development of a methodology which will result in a higher quality software at a reduction in cost of between 30% to 50%.

**W77-70691** **310-10-26**
Goddard Space Flight Center, Greenbelt, Md.
**ATTITUDE - ORBIT ANALYSIS**
E. J. Lefferts 301-982-5508
(310-10-22)

The objectives of this RTOP are to increase the efficiency and decrease the resources needed to meet the requirements for spacecraft missions by (1) the use of new data types and on-board processing in order to decrease the quantity and usage of tracking and telemetry data for attitude and orbit determination and control, (2) the provision of generalized and flexible computing systems utilizing on-board and small ground computers in order to increase the speed of information flow to the user and to reduce the demand upon the central computer facility, and (3) the provision of standardized sensor combinations, telemetry interfaces and computational algorithms suitable to meet the demands of changing computer environment in order to effect a reduction in the attitude and orbit determination software development cost. The approach involves the development of computational software to permit the analysis and evaluation of coupled attitude-orbit-landmark registration process. Such studies were started with simple attitude models. Extension to the use of wheel speed data and later to the use of gyro and star camera data will be made. The generation of efficient reliable algorithms suitable for minicomputer and on-board implementation of autonomous attitude and orbit determination and control will be continued. Attitude determination algorithms for on-board processing have been sized and timed for the NASA Standard Spacecraft Computer (NSSC). Extensions of the orbit processing to the consideration of GPS data will be made. Simulations of on-board processors with their fixed point arithmetical computations will facilitate the evaluation of developed algorithms and their software implementation.

**W77-70692** **310-10-42**
Goddard Space Flight Center, Greenbelt, Md.
**FREQUENCY STANDARD SOURCES**
Victor S. Reinhardt 301-982-5946
(644-03-15)

The RTOP is to develop improved atomic hydrogen frequency and time standards with a frequency stability of 2 x 10 to the minus 15th power at 10,000s, and with a frequency accuracy of 1 x 10 to the minus fourteenth power, as well as to aid in the transfer of existing hydrogen maser technology to provide a contractor source of operational hydrogen masers for meeting critical NASA applications such as optical and microwave range and range rate tracking, very long baseline interferometry, and the Spacelab Applications Facility. Task A (Operational Hydrogen Maser Standards) is to construct instrumentation for the Frequency Standards Facility, to design and test an improved receiver system and a hybrid cavity maser, and to transfer maser technology to APL. Task B (Concertina Maser Calibration Standard) is to improve design, to conduct operational testing and a stress test on teflon, to examine operation at elevated temperatures, to measure the second order Doppler shift, and to determine the feasibility of a zero wall shift maser. Task C (Atomic Beam Standard) will continue the development of the MOSFET detector; it also includes redesign of the machine for new detectors, and operational testing of the new design.

**W77-70693** **310-10-43**
Goddard Space Flight Center, Greenbelt, Md.
**ADVANCED LASER RANGING SYSTEMS DEVELOPMENT**
Johnson T. S. 301-982-5583
(161-02-01; 506-20-33)

The objective is the field test, evaluation and intercomparison of advanced prototype laser ranging systems to establish the reliability, economy and accuracy of the systems before acceptance and deployment in the operational laser ranging networks. This RTOP will use components and subsystems developed under OAST RTOP 506-20-33 and OA RTOP. 161-02-01, and will integrate these technologies into complete laser ranging ground stations. These advanced ranging systems will be evaluated using the existing tracking facilities at the Goddard Optical Research Facility (GORF) and the corner reflector equipped satellites presently in orbit as well as planned geodetic satellites such as LAGEOS. Range residuals will be evaluated using contemporary geopotential models and stability and absolute accuracy established through the use of ground based targets and system intercomparisons. Program goals include the demonstration of 5 cm range accuracy before 1977 and the achievement of operational 2 cm accuracy by the early 1980's. In FY 77, extensive field tests of a low signal level system employing a high pulse rate (30 pps) mode locked, frequency doubled Nd:YAG laser will be conducted. Such systems operating at relatively low peak powers offer potential reliability and cost advantages when deployed in the operational laser ranging networks.

**W77-70694** **310-10-60**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**NAVIGATION ACCURACY ANALYSIS**
T. H. Thornton, Jr. 213-354-4877
(310-10-61; 310-30-69; 310-10-62; 310-10-64)

DSN tracking system uncertainties limit spacecraft navigation capability. The current limit is about 100 km at Mars. A ten-fold increase in delivery accuracy is anticipated for future outer planet missions. Hence, it is important to determine limiting uncertainties and possible improvements. The effects of the transmission media and uncertainties in platform parameters (DSS location, UT1, and polar motion) represent limitations for future missions, especially those to the outer planets. Methods of removing these limitations either by calibration or by utilization of less sensitive data will be developed and analyzed. Calibration techniques include the use of the S/X band dual frequency system for the charged particle component of the transmission media and the water vapor radiometer for the wet component of the troposphere, while a VLBI system is being developed to reduce the uncertainties for the platform parameters. Also, data types being developed which are less sensitive to the above limitations include the use of two DSS to obtain differential VLBI data which measure the spacecraft position with respect to an extragalactic radio source and the use of a single DSS to track one spacecraft with respect to a second. In addition to reducing limitations in navigation capability due to the tracking system, this RTOP develops tracking techniques to overcome other limitations such as those arising from the trajectory or spacecraft characteristics. Examples include multi-station tracking where the differencing of simultaneous range

from widely separated DSS is used to overcome the degradation of single station data for low declination spacecraft, and the differencing of simultaneous Doppler is used to overcome unmodeled spacecraft forces.

**W77-70695** **310-10-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**RADIO METRIC INSTRUMENTATION DEVELOPMENT**
R. L. Sydnor 213-354-2763
(310-10-60; 310-20-65; 310-20-66; 310-30-69)

The objective of this RTOP is to develop and demonstrate high quality instrumentation and efficient techniques for DSN radio metric data acquisition to support flight project navigation needs over the next decade for outer planet satellite, orbiter, and entry probe missions. Specific requirements are determined by RTOP 310-10-60 and include the following: (1) accurate frequency and time standards for differenced range and Doppler measurements, (2) VLBI instrumentation systems for interstation time synchronization and station location measurements, (3) improvement in group and phase delay stabilities of tracking station equipment for accurate range, Doppler and VLBI measurements, (4) troposphere and ionosphere delay calibration measurements for calibration of radio metric data, and (5) instrumentation for flight project radio science support of precision occultation and relativity measurements. Specific instrumentation and techniques under development include: (1) hydrogen masers and associated nanosecond clocks and performance monitoring equipment; (2) a VLBI instrument for UT1/pole motion, and station location measurements to 50 cm, and interstation time synchronization to 10 nanoseconds; (3) stabilized system cables and RF multiplier chains, and precision phase calibration of equipment down to 1/2 cm; (4) investigation of the water vapor radiometer technique as a means of measurement of the troposphere delay down to 2-3 cm; and (5) studies of radio metric methods to improve quality of Doppler to 10 cm over 10 hours and range to 30 cm for use in relativity verification experiments. A systems approach is being used in these developments to assure that balanced error contributions result and efficient low life cycle cost design approaches are utilized.

**W77-70696** **310-10-64**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**X-BAND UPLINK DEVELOPMENT**
R. L. Leu 213-354-5692
(310-20-66; 310-30-69)

This RTOP develops an X-band radar capability to obtain operational experience at this frequency, to prepare for an X-band uplink for flight project support and to obtain planetary data to assist in future flight project mission design. A system gain of up to 7 dB over S-band radar is achieved on targets without dense atmospheres. Thus, better experiments can be done on the rings of Saturn, on Mercury, on Mars mapping to obtain better data for VK 75, on Jovian Moons, and on asteroids. The newer capability available at X-band allows finer range gates which can be used to improve mapping and altitude resolution and obtain better emphemerides as well. The operational experience has proved that: (1) 400 kW at X-band is attainable in one waveguide, (2) the transmitter appears to be suitable for an X-band uplink, and (3) high quality, high speed protective circuits are critical for reliable operation of the transmitter and for the klystrons. To provide this transmitter capability, several new system elements were required: (1) a low-noise/high-power radar feed, (2) a 400 kW X-band power amplifier, (3) an exciter/frequency multiplier, and (4) high-power transmission line devices. Modifications were required to the existing operational S-band transmitter assemblies in order to provide high voltage, coolant and dual klystron control. Additional effort was required in FY 76 to redesign klystron protective circuits, and to increase the overall system reliability so that intensive Mars radar surveys for the VK 75 project could be accomplished. The X-band receiver subsystem, including an X-band traveling wave maser, in use at DSS 14, was used for the X-band radar development. Block IV exciter modules were used to drive a new frequency multiplier to obtain the X-band frequency. The major microwave components developed, in addition to water-cooled waveguide, were a polarizer, waveguide switches and an RF power combiner. The combiner is used to add the outputs of two 200 kW klystron amplifiers to attain 400 kW power output. The X-band radar was operational in December 1974. The computer-controlled modulation, detection, and frequency control assemblies that are required for the X-band radar were developed under RTOP 310-30-69.

**W77-70697** **310-20-27**
Goddard Space Flight Center, Greenbelt, Md.
**NETWORK TIMING AND SYNCHRONIZATION TECHNOLOGY**
A. R. Chi 301-082-2502

The objectives of this research are to study and develop techniques for time synchronization, to coordinate time determination methods and dissemination formats to meet NASA needs and network requirements, and to conduct theoretical investigations and experimental tests for network applications. The approach has been the development of a worldwide time synchronization system through which time can be disseminated to the network users. By coordination with the Navy, the OMEGA Navigation System has been used to test a technique developed by NASA to extract microsecond time from two very low frequency (VLE) signals on a worldwide basis. A receiver specifically designed to receive the OMEGA signals has been tested. The system precision is 2 microseconds worldwide. A more advanced system using a synchronous satellite to transpond a time synchronized pseudo random noise (PN) coded signal from a ground station to the network stations has been investigated and tested under another program using application technology satellites (ATS). The accuracy achieved using the two way satellite transponding mode is 50 nanoseconds. The application of this technique to the Tracking & Data Relay Satellite System (TDRSS) is being developed.

**W77-70698** **310-20-31**
Goddard Space Flight Center, Greenbelt, Md.
**A GROUND ANTENNA FOR WIDEBAND DATA TRANSMISSION SYSTEMS**
Richard F. Schmidt 301-982-4920

Future advanced spacecraft systems will transmit data to the ground at rates much higher than those of current operational systems. The Earth Observation Satellite (EOS) will transmit high resolution color TV either directly to a ground station or via Tracking and Data Relay Satellites (TDRS). The TDRS will transmit signals from EOS and other satellites which require total TDRS bandwidths approaching 1 GHz. Existing NASA ground stations are not equipped for such data rates. Future wideband communication by TDRS, EOS and other projects requires use of frequencies at which the necessary bandwidth can be allocated. A wideband (approximately 1 GHz) system requires a high performance ground antenna system. Emphasis on overall system efficiency will be essential to an economically feasible ground station. In particular, techniques and components will be developed which yield high efficiency antenna systems, feed systems and low noise preamplifiers. In addition, dichroic subreflector techniques permitting simultaneous and efficient operation of an antenna at different frequencies without degradation of overall performance or flexibility will be refined. Analytical procedures and design tools will be further developed to support the specific requirements of these advanced antenna systems and the general antenna development program.

**W77-70699** **310-20-32**
Goddard Space Flight Center, Greenbelt, Md.
**HIGH RELIABILITY PRECISION CONTROL FOR ANTENNAS**
A. J. Rolinski 301-982-4977

The objective of this RTOP is the development of a reliable, high accuracy control system for large satellite tracking antenna systems. The future network requirements are geared to system operation at Ku-Band frequencies. Thus, the existing S-Band antenna systems will require an improvement in the tracking accuracy from the present 0.9 mrad to 0.2 mrad. Furthermore, there is a trend toward reducing the number of tracking stations while maintaining and even increasing the requirements on data bandwidths. Since the control loop is a serial system, it must experience trouble-free operation during the mission support

period. Thus, link downtime has to be minimized by providing a high reliability control system and by reducing the chances of catastrophic failures by applying efficient alignment and calibration routines prior to mission support. These objectives are met by use of a mini-computer in the antenna control loop. An experimental system, the Computer Controlled Antenna System, has been developed under this RTOP and is in operation at the Network Test and Training Facility (NTTF). The capabilities of this system will be extended by the implementation of control algorithms to improve the tracking accuracy and by providing computer routines for pre-pass checkout of the antenna control system to minimize antenna downtime.

**W77-70700** **310-20-46**
Goddard Space Flight Center, Greenbelt, Md.
**RF TECHNOLOGY FOR TDRSS USER SPACECRAFT**
F. J. Logan 301-982-4901
(506-20-24)

The objective of the work under this RTOP is to achieve technological advances in RF and antenna systems in order to satisfy the future requirements of spacecraft projects that require the near global real-time coverage of the Tracking and Data Relay Satellite System (TDRSS). It: (1) identifies the basic operational requirements of these missions; (2) investigates RF components and types of antenna that are available to attain the required parameters; and (3) develops system designs incorporating the optimum subsystems to permit the spacecraft projects to obtain proven reliable flight hardware within a reasonable time frame. OTDA has notified GSFC that funding for this RTOP will be terminated, after the FY 76 transition period. This curtailment of funding will severely impact the long-term goals of the RTOP. The Jet Propulsion Laboratory (JPL) has been designated the lead center for the development and management of the NASA Standard Transponder (NST), and the TDRSS transponder program has been transferred to JPL. GSFC is still responsible for proper interface with the TDRSS and will insure the integrity of the JPL specifications with regard to both the GSFC user projects and the TDRSS signal design compatibility. This RTOP supports the program by sub-allocating $600 K to JPL for the development of the transponder.

**W77-70701** **310-20-65**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ANTENNA SYSTEMS DEVELOPMENT**
R. J. Wallace 213-354-4734
(310-10-61; 310-20-66; 310-30-68; 310-30-73)

This RTOP develops the technology for increasing the communications capabilities of the DSN ground based antennas as part of optimizing the overall flight/ground communications link for planned NASA missions to outer planets. Communications capability is measured by the antenna figure of merit (ratio of gain to receiver system noise temperature); usable operational frequencies (S, X or K-bands); and environmental limits of operation. The technology developed provides communication options for spacecraft planning in both the telemetry and radio metric data types. The megabit data rates available at K-band require improved reflector surfaces and antenna pointing techniques at this frequency. The VLBI navigation techniques impose additional requirements on structural stability and the ability to point the antenna without reference to the received signal direction (blind pointing). The steadily increasing costs for new construction and modification of antenna structures is a major influence in the development of low cost technology to meet evolving needs of the DSN. Flight/ground tradeoff studies are used to balance the needs between communication link requirements, spacecraft parameters and DSN related capabilities. Overall increased performance and economy in supporting spacecraft communications requirements, based on these tradeoff studies, are the key objectives of this program. Advances in ground antenna performance are sought in the areas of microwave techniques and in antenna structural, mechanical and pointing systems. Emphasis in the microwave area is on the study of dual frequency techniques at X- and K-band, and on the development of effective alternates to the present reflex feeds, such as concentric dual frequency feeds, for combinations of S-, X-, and K-bands. Advanced analytical techniques are used in structural design for development of antenna configurations which have improved performance and lower cost.

**W77-70702** **310-20-66**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**RADIO SYSTEMS DEVELOPMENT**
Macgregor S. Reid 213-354-3332
(310-10-61; 310-20-65; 310-20-67)

The objective is to improve the spacecraft-to-ground radio system elements of the communications link in order to meet the future navigation and high data rate telecommunications requirements of the planetary exploration program. Future missions to the outer planets will require sensitive, radio frequency interference (RFI) resistant, and stable, higher frequency receivers and wideband radio communications for high rate video, telemetry, navigation, and radio science data. They will also require calibration and models of the propagation medium and of the DSN ground radio parameters for efficient link design. An X-band weather model for link design purposes has been produced and additional data is being obtained to update the model for this use in mission planning. Equipment for Ku-band weather data is being fabricated and Ku-band data will be acquired in the near future. An X-band maser and closed cycle refrigerator system with an input noise temperature of 2.5K and a bandwidth exceeding 100 MHz, at high gain with high reliability, is being constructed. Techniques for operating the closed cycle cryostat at 3K are being developed for increased gain-bandwidth product. Technologies developed for S and X-band traveling wave masers (TWM) will be applied to Ku-band. In addition, parametric upconverters are being investigated for use in multifrequency, wide band, ultra low noise amplifiers at S, X, and Ku-bands, which use a single TWM at K-band. Separate upconverters are provided for each band. Upwards of 300 MHz bandwidth can be obtained; this wide bandwidth capability will be particularly useful for DSN RFI investigations. In FY'77 work will be initiated on radio frequency interference susceptibility reduction. The objective of this task is to develop signal filtering, modulation and detection techniques to minimize effects of RFI in the DSN.

**W77-70703** **310-20-67**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**DIGITAL SYSTEMS DEVELOPMENT**
R. A. Winkelstein 213-354-3843
(310-10-61; 310-10-66; 310-30-69)

The objective of this RTOP is to develop data handling systems which permit effective communications between Earth and spacecraft for mission types of the next decade. Specific objectives include the development of digital receiver technology for rapid reconfiguration and increased telemetry data rate reception, methods for the improved use of the spacecraft-ground telecommunications link, and means for detection and early warning of radio frequency interference (RFI) signals which might disrupt reception of spacecraft telemetry. Development of digital receiver technology consists of digitizing the received signal at the receiver intermediate frequency of 10 MHz and thereafter using digital phase locked loop techniques for carrier tracking. In addition, telemetry digital demodulation methods will be developed for data rates in the 5 megabit per second range. To improve telecommunication link performance, analysis is being carried out and methods developed for threshold communications over fading and dispersive channels such as encountered when Pioneer Venus 78 transmits through the turbulent Venus atmosphere. The analysis and development of improved end-to-end coding techniques for uplink command signals to the spacecraft and downlink telemetry signals from the spacecraft will also contribute to link utilization. For RFI detection, a multichannel spectrum analyzer will be developed covering a bandwidth of 20 MHz with a resolution of 125 Hz.

**W77-70704** **310-30-68**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**STATION AND NETWORK MONITOR & CONTROL TECHNOLOGY DEVELOPMENT**
Robert M. Gosline 213-354-4942
(310-20-67; 310-30-69; 310-40-72; 310-40-73)

The general objective of this effort is to increase the number of automatic tracking station control and monitor functions accomplished without operator intervention, and to develop techniques for unattended station operation using remote control from a central location. This activity contributes directly to the effort for developing means to increase network productivity, and hence more effective support of flight projects, and reduction of network life cycle costs. The approach is to collect an automated station data base by developing an unattended station and using realistic demonstrations to acquire the following types of information: (1) equipment and software costs, (2) subsystem performance criteria including reliability and downtime, (3) subsystem controller design requirements, and (4) intra-station and network control and monitoring design requirements. This data base will be used in RTOP 310-40-73 to predict life-cycle costs of automation approaches, prior to commitment of the investment necessary to implement an automated network. Substantial progress has been made on the automation of data-related station subsystems such as telemetry and command; the present effort is directed toward automating RF and electro-mechanical subsystems. Several key automation efforts are underway, using DSN Deep Space Stations (DSS) for test beds.

**W77-70705** **310-30-69**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**TRACKING STATION SYSTEMS TECHNOLOGY**
R. R. Green 213-354-3015
(310-20-65; 310-30-68; 310-40-72)

The objectives of this RTOP are to develop, test and demonstrate new station systems capability and new network technology required to support deep space missions in the next decade. The major vehicle used to demonstrate the new technology developed is the planetary radar system at both S and X band frequencies. The major effort during FY 77 will be to develop the equipment necessary to expand the current S-band radar interferometer from two Deep Space Stations (DSS-13 and 14) to three stations (DSS-11, 13, and 14). Additional components to be added to the Radar Data Acquisition system at DSS-14 to support the three-station interferometer include an additional range coder/demodulator set to handle the data stream from DSS-11, a wideband 80 MBPS magnetic tape recorder to do pre-range demodulation sample recording, and new magnetic tape units or disks to record the reduced data for analysis. To avoid requiring expensive hydrogen maser frequency standards at each of the three stations a precision frequency and timing distribution will be developed. This distribution system will allow the precision frequencies from one hydrogen maser to be distributed to all stations in a complex with acceptable accuracy and stability. The X-band radar system will also be used during this year to observe the rings of Saturn, satellites of Jupiter, and targets of opportunity such as asteroids and comets. Some benefits obtained from the planetary radar experiments which enhance flight project support include data on planetary surface characteristics and updated planetary ephemerides.

**W77-70706** **310-40-25**
Goddard Space Flight Center, Greenbelt, Md.
**AUTOMATIC SYSTEM FOR COMPUTER PROGRAM DOCUMENTATION**
E. P. Damon 301-982-6886

The purpose of the system is to help document, monitor, and control software development projects. It is written in COBOL which makes the system machine independent. It can operate in either a batch or interactive mode which makes it easily adaptable to a user's style of development. It can monitor all phases of software development projects. Data can be gathered by the monitor which is useful in categorizing errors, predicting programmer productivity, and validating software reliability models. Programmer teams using structured programming techniques and topdown development organization have proven to be very effective. Most documentation is manually produced as part of programmer team efforts. A very effective new documentation technique is the HIPO (Hierarchical plus Input-Process-Output) package which consists of a set of diagrams that graphically describe function from the general to the detail level. These techniques will be developed to automatically produce HIPO diagrams using the computer. Furthermore, the system will be applied to monitor development projects and to gather programmer productivity data and program error data. The productivity data will be used to develop an accurate programmer productivity model. This model will be useful for accurately estimating project cost and completion times. Program error data will be useful in validating existing software reliability models and for developing new models.

**W77-70707** **310-40-26**
Goddard Space Flight Center, Greenbelt, Md.
**PROTOTYPE COMPUTER COMMUNICATIONS SYSTEM FOR OPERATIONS SUPPORT COMPUTING IN THE 1980'S (DEMOS)**
R. L. Larsen 301-982-2777

This RTOP addresses the development of an operations support computing facility for the 1980's. The facility is presently called the Distributed Environment for Mission Operations Support (DEMOS). It will exhibit the following properties: (a) fault-tolerant reliability, (b) high availability, (c) configuration flexibility, (d) potential for incremental growth, and (e) ease of operation. The objective of this RTOP is to develop a microprocessor-controlled prototype local interprocess communication system exhibiting high bandwidth, reliability, and availability. This system is seen to be crucial to the successful development of DEMOS, which is to be a resource and load sharing local distributed computing facility. As a result of this RTOP, viable mechanisms for controlling such an environment can be studied and developed.

**W77-70708** **310-40-36**
Goddard Space Flight Center, Greenbelt, Md.
**AUTOMATIC DATA HANDLING**
J. C. Rodgers 301-982-4189

Improvements to meet the large increases in support requirements demanded by NASA's future space programs specifically include a higher level of automation for Goddard Space Flight Center (GSFC) facilities resulting in increased data and information exchanges between the various GSFC facilities. This RTOP shall study methods of handling data and information and shall result in the design and development of a prototype Integrated Telecommunications Distribution System providing a communications network between the operational M&DOD computer systems. The Integrated Telecommunications Distribution System will interconnect existing M&DOD computer systems and will permit any computer on the telecommunications network to communicate with any other computer on the network.

**W77-70709** **310-40-39**
Goddard Space Flight Center, Greenbelt, Md.
**IMAGE PROCESSING FACILITY PERFORMANCE EVALUATION AND IMPROVEMENT**
J. Y. Sos 301-982-2841

The GSFC Image Processing Facility (IPF) is being implemented to provide image processing support for Landsat, AEM-HCMM and Nimbus-G. This RTOP supports the IPF development in the areas of operational concept definition and the evaluation of efficient digital image processing algorithms. Algorithms evaluation studies are carried out in the following areas: (1) digital resampling (nearest neighbor vs. cubic, etc.), (2) extraction of geodetic control points from digitized visible and thermal IR data, and (3) temporal registration of digital data. To assure high system performance, it is necessary to develop efficient performance monitoring techniques, develop parameters to characterize process and product quality, and obtain instruments to implement these techniques in conjunction with planned IPF hardware. The Image Display and Recording System (IDARS), a test bed for evaluation of new techniques, is now under development. A major IDARS task will be the development of automated monitoring of geometric correction accuracy for digital data. Future earth obervation sensors will require a storage volume of 5 x 10 to the 14th power bits of image data in an operational environment. Studies of advanced archival data storage systems to meet future IPF requirements will be conducted. This work will be limited to conceptual design studies.

**W77-70710** **310-40-40**
Goddard Space Flight Center, Greenbelt, Md.
**POCCNET: PAYLOAD OPERATIONS CONTROL CENTER COMPUTATIONAL SYSTEM OF THE 1980S**
R. DesJardins 301-982-6223

The goal of this RTOP is to develop a control center computational system design (hardware/software) for GSFC for the 1980s, christened POCCNET (Payload Operations Control Center Network), embodying the following features: (a) robust, fail-soft hardware/software design, (b) high visibility of systems implementation status and operational state, (c) virtualization of computational system functions (subsystem functional independence), (d) flexibility and ease of reconfiguration, (e) simplified integration and test of applications systems, (f) reduced development time and cost, (g) special attention to human interfaces and to software engineering, and (h) low cost standard software and supporting services for the Multimission Modular Spacecraft (MMS) and other standard envelopes of requirements. The effort is divided into four elements: (1) to identify probable computational requirements on GSFC POCCs anticipated in the 1980s due to MMS, TDRSS and Shuttle; (2) to identify applicable advanced technologies, and develop specifications for minicomputers, serial channel and telemetry processor; (3) to identify applicable software engineering methodologies, including languages and software design and management methodologies; and (4) to design POCCNET subsystems in both the systems and applications areas.

**W77-70711** **310-40-41**
Goddard Space Flight Center, Greenbelt, Md.
**COMPUTER USAGE TECHNIQUES**
P. B. Schneck 212-678-5617

The objective of this RTOP is to develop and apply techniques for increasing the operating efficiency of current computer systems, and to determine the cost/effectiveness of array processing systems developed with low cost, standard, off-the-shelf hardware. The mathematical model of computer system utilization and performance will continue to be extended in order to increase operating efficiency. The model acts on parameters reflecting workload distribution, job size, I/O configuration, memory capacity, etc. The output will permit prediction of system performance as a function of the input parameters and will promote better decisions-making ability concerning equipment acquisition, configuration modification or workload scheduling. A prototype array processing system, consisting of a minicomputer and an available array processor, will be constructed. This system will be used to run problems representative of suitable large scale codes in use at GSFC. The Fortran language and associated library routines will be used to demonstrate that high performance systems can be constructed from standard, low cost subsystems. Some actual problems (or problem segments) will also be coded on the system. A second array processor is expected to be acquired next year to demonstrate the ability to increase the size and capability of the system to that necessary for large scale problems.

**W77-70712** **310-40-72**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**NETWORK CONTROL AND DATA PROCESSING DEVELOPMENT**
J. W. Layland 213-354-2757
(310-30-68; 310-30-69)

The objective of this RTOP is to develop the techniques necessary for the efficient and cost-effective application of computational resources to the jobs of the DSN. Software/Hardware design methods being devised in this RTOP will improve management control of system development by facilitating the top-down hierarchical expansion from functional requirements to detailed software and hardware design. The Advanced Systems segment of the DSN Programming System work utilizes pathfinder projects such as the Machine Independent Design of a language processor for MBASIC to generalize a Software Methodology appropriate to DSN needs. This Methodology in turn contributes to Standard Practices, Standard Languages, etc., for DSN Implementation to improve the overall productivity of the DSN. In support of this work, mathematical analysis is applied to several specific areas of Data Systems Design: hardware element utilization, complexity of structured and non-structured programs, inherent complexity of data manipulation programs, and theory of data base design. Maintenance of logical hardware in the network environment represents a sizeable cost item for the DSN. This cost is being attacked through the development of a standard set of logical building blocks, the Control and Computational Modules, which will be used for the fabrication of a variety of digital systems, from a dedicated signal processor to a multipurpose digital controller. The automation development experiments led by RTOPs 310-30-68 and -69 are supported in part by computer technology developments in this RTOP. This involvement includes but is not limited to participation in the development of computer communications protocol, interfaces, and software; and the evaluation of impacts of changing minicomputer/microcomputer technology on future Network implementation of automated subsystems.

**W77-70713** **310-40-73**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**NETWORK PRODUCTIVITY RESEARCH**
S. A. Butman 213-354-2759
(310-30-68; 310-30-69; 310-40-72)

The overall objective of this RTOP is to aid in increasing the productivity of the DSN to ensure effective use of NASA resources for tracking and data acquisition support of flight projects and other end users. There are two key parameters to be optimized: (1) Network Productivity, and (2) DSN Cost Effectiveness. Network productivity is defined as the ratio of end user station hours to total operations and operations support man-years expended. DSN Cost Effectiveness is defined as the ratio of end user tracking hours to total DSN funding. This RTOP devises conceptual models, analytical methods and system design techniques to increase the value of these key parameters, with the overall impact of reducing life cycle costs of new equipment and software, and capabilities already installed, including operations and maintenance resource needs. Data on equipment down time, maintenance procedures and history, equipment operator needs, and like information are collected in a data base and are used in the analysis, modeling and techniques development so that solutions to problems are realistic and based on actual experience. The key results of this effort will: (1) permit DSN management to assess the effect of resource allocation decisions prior to implementation of these decisions, and (2) provide design guidelines to subsystem and system designers which will result in minimum life cycle costs for equipment and software.

# OFFICE OF ENERGY PROGRAMS

## Energy Technology Programs

**W77-70714** **776-10-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SPS IMPACT AND BENEFITS STUDY (JOINT ERDA/NASA PROGRAM)**
M. E. Alper 213-354-6948

The NASA Office of Energy Programs is presently conducting a study of the potential utility of large orbital central power stations as energy sources for terrestrial applications. As part of this study, which will continue in FY-76, a survey of potential terrestrial energy conversion systems is being made in order to provide a basis for assessment of orbital central power stations. The terrestrial systems studies include system performance, operations, costs and impact. Terrestrial power plant types include standard and advanced fossil and nuclear energy systems, and several types of solar energy systems. Conventional and more advanced methods of energy transmission are also included. In addition to the comparative assessment, an evaluation of the impacts and benefits of space based power systems will begin in the latter part of FY-76 and will continue through the transition period and into FY-77.

**W77-70715** **776-10-04**
Lyndon B. Johnson Space Center, Houston, Tex.
**SPACE SOLAR POWER SYSTEMS DEFINITION STUDIES (JOINT ERDA/NASA PROGRAM)**
R. O. Piland 713-483-4071

This program consists of system analysis studies to support the continued definition and evaluation of the space solar power concept. This particular study will be directed towards the evaluation of various design approaches and related program parameters in order to provide information to enable an SPS (Satellite Power System) Technology Advancement decision during calendar year 1979. The effort will consist of a combined in-house and contracted effort which will build on the present preliminary JSC in-house study to be concluded July 1, 1976. It is proposed to achieve the 1979 milestone in two phases. Phase I will produce interim results at the end of calendar year 1977 to support the ongoing program.

**W77-70716** **776-11-11**
Marshall Space Flight Center, Huntsville, Ala.
**SATELLITE POWER SYSTEMS (JOINT ERDA/NASA PROGRAM)**
C. H. Guttman 205-453-2796

The primary objective of this work effort is to perform an in-depth advanced systems and technology assessment of the SPS to enable the selection of the systems/subsystems/components for advanced technology development by 1980. Typical goals to be achieved in FY77 in accomplishing the primary objective are to: (1) develop a preliminary 1980-on implementation plan; (2) continue to define, in-depth, the SPS concept system/subsystem requirements and integration; (3) continue economic assessment of the SPS; (4) define the relationship of SPS to other programs; and (5) initiate needed ground technology investigations of SPS critical subsystems/components. This work effort is to be accomplished by an in-house team with R&D funds to support both the advanced systems study and technology assessment areas. The R&D funds will be primarily used for contracted activities.

**W77-70717** **776-13-12**
Marshall Space Flight Center, Huntsville, Ala.
**ENVIRONMENTAL EFFECTS OF SATELLITE POWER SYSTEMS (SPS) - OPERATIONAL SPACE ENVIRONMENT**
G. F. Von Tiesenhausen 205-453-2789

The objective is to determine the effect of the operational space environment on the Satellite Power System (SPS) in order to provide protection for the SPS and assure that the planned 30-year operational lifetime of the SPS is obtained. It will also be necessary to determine the amount of charging and arc discharging that will occur in order to design for these effects. The approach will be to: (1) determine the magnitude of potential spacecraft charging, (2) define the natural plasma environment at synchronous orbit, (3) determine the meteoroid shield requirements for the crew habitat, (4) prepare a mathematical simulation of the population and distribution of all man-made earth orbiting satellites and determine the amount of resulting space debris, and (5) determine analytically the damage probability curves for SPS equipment.

**W77-70718** **776-13-21**
Lyndon B. Johnson Space Center, Houston, Tex.
**SPS MICROWAVE BEAM EFFECTS (BIOLOGICAL EFFECTS NOT INCLUDED IN THIS RTOP)**
R. O. Piland 713-483-4071

The Solar Power Satellite Concept involves the transmission of power from space to earth via microwave radiation. The objective of this RTOP is to assess the effects of microwave beam interaction with regions of the atmosphere, and the effects of the beam on astronomical observations, communications, and electronic equipment. The approach to achieving the objectives of the RTOP will involve: (1) an analysis of the interaction of the beam with the ionosphere, (2) the development and execution of a series of tests utilizing the Arecibo antenna, (3) an analysis of sidelobe levels for RFI effects on astronomy and communications, (4) an identification of electronic equipments, i.e., aircraft systems, likely to encounter the beam, and (5) testing of selected equipments.

**W77-70719** **776-13-71**
Ames Research Center, Moffett Field, Calif.
**BIOLOGICAL AND ECOLOGICAL IMPACT OF ENERGY TRANSMISSION BY MICROWAVE BEAM (JOINT ERDA/NASA PROGRAM)**
J. C. Sharp 415-965-5100

NASA is currently assessing the feasibility of a Space Power Satellite (SPS) to generate electrical power in space and transmit it to earth by microwave beam. The environmental impact from the transmission, received over many square miles continuously for 30 years appears to be far less than that from many other proposed solutions to the energy crisis, but many aspects have not been researched or tested. The biological and ecological consequences on all forms of fauna and flora to be illuminated need to be well defined. In addition, the potential hazard to operational personnel from acute exposure and low-dose chronic exposure must be evaluated in order to establish areas of restricted use around the receiving area. An initial short-term funded effort (definition Phase) will be implemented to develop a 3-year research program that emphasizes the definition of major effects and anticipated problems, with suggested approaches to solutions to be researched in subsequent years. The initial 5-month study plan will be presented and documented for peer review and the accepted plan pursued for an intensive 3-year research program (Phase A). Results of that research will be assembled in a form suitable for use in decisions by NASA management to extend commitments to the Space Power Satellite Concept and to further biological and ecological studies on mechanisms and interactions (Phase B). A further extension of this effort (Phase C) would be the development of operational procedures, site selections and preparation of Environmental Impact documentation.

**W77-70720** **776-21-11**
Marshall Space Flight Center, Huntsville, Ala.
**SOLAR HEATING AND COOLING DEVELOPMENT FOR DEMONSTRATION PROGRAM (REIMBURSABLE)**
Donald R. Bowden 205-453-1248
(776-23-01)

For a brief technical summary, justification, operating plan, review and reporting of this RTOP see MSFC Program Plan for Solar Heating and Cooling Development in Support of the Demonstration Program, SHC-1003A, Revised January 20, 1976.

**W77-70721** **776-22-11**
Marshall Space Flight Center, Huntsville, Ala.
**SOLAR HEATING AND COOLING COMMERCIAL DEMONSTRATION PROGRAM (REIMBURSABLE)**
Donald R. Bowder 205-453-1248

The MSFC and the NASA Office of Energy Programs (OEP) have agreed to support the Energy Research and Development Administration (ERDA) 'Commercial Demonstration Program.' This agreement is documented by Interagency Agreement No. E (49-26)-1037 between NASA and ERDA dated Dec. 12, 1975. The MSFC Program Plan for accomplishing this support is SHC-1004.

**W77-70722** **776-22-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**FIXED TILT VEE-TROUGH COLLECTOR (REIMBURSABLE)**
M. E. Alper 213-354-6948

The objective of the proposed program is to investigate the performance of a solar collector employing non-tracking reflectors integrated with a fixed vacuum tube receiver. The effort will optimize the collector's performance to yield a minimum cost ($/MBTU) for the energy collected and develop a design which will be reliable in performance and which can achieve long life. The proposed effort will construct a test bed collector, perform a series of experiments, develop an analytical thermal model of collectors of this type, and conduct optimization studies leading to a minimum cost ($/MBTU) collector configuration. Finally, a phase two plan would be developed for the construction of a prototype collector using the optimized configuration.

**W77-70723** **776-41-11**
Marshall Space Flight Center, Huntsville, Ala.
**DEVELOPMENT OF LONGWALL MINING GUIDANCE AND CONTROL SYSTEMS (REIMBURSABLE)**
R. E. Pease 205-453-4113

The primary objective of this project is to study and develop guidance and control systems which will make a significant contribution to the Bureau of Mines longwall automation goals and which can be demonstrated on an advanced technology longwall system by the end of 1980. Specific objectives of this plan are as follows: (1) the development of an automated vertical control subsystem for the longwall shearer cutting drums to follow the boundaries of the coal seam, which will extract the desired portion of the coal, while minimizing the amount of rock or non-coal product taken, (2) the definition of requirements and a practical design concept for automating the forward advance of a longwall mining system, which will maintain the desired lateral and vertical alignment of the coal face; and (3) the definition of requirements and a practical design concept for a remote control station, which will display and control automated operations.

**W77-70724** **776-41-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**LONGWALL/SHORTWALL MINING EQUIPMENT RELIABILITY, MAINTAINABILITY AND COST EFFECTIVENESS STUDY (REMIBURSABLE)**
M. E. Alper 213-354-6948
(778-90-02)

The underground coal extraction industry currently has demands upon it to increase production and provide a larger portion of the nation's energy. The longwall/shortwall mining methods, presently in use by the mining industry, are the most promising advanced mining methods. Reliability and maintainability, however, have contributed heavily to prevent both longwall and shortwall mining from reaching their full potentials. The longwall/shortwall maintainability and cost effectiveness study will apply the analytical techniques of reliability and maintainability analysis to the goal of increasing coal production. The expected term of the task is nine months.

**W77-70725** **776-42-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ADVANCED COAL EXTRACTION SYSTEMS DEFINITION (REIMBURSABLE)**
M. E. Alper 213-354-6949
(778-90-02)

Since 1969, underground mining of coal has experienced a substantial decrease in productivity. The Bureau of Mines has suggested that if the nation is to be adequately supplied with coal, new concepts in underground mining need to be developed to meet the increased demand. This RTOP is to cover the activities of Phase I in the NASA Program Plan for Advanced Coal Extraction Systems Definition dated January 7, 1976. The objective of Phase I is to establish performance requirements for Advanced Coal Extraction Systems.

**W77-70726** **776-83-11**
Marshall Space Flight Center, Huntsville, Ala.
**EARTH BASED SOLAR POWER CONVERSION AND DELIVERY SYSTEMS**
Hugh J. Dudley 205-453-2813

This program will: (1) define experimentally and analytically the capability of the Fresnel lens solar concentrator to provide thermal energy in the 400 F to 700 F range, (2) identify practical applications of the Fresnel lens concept which potentially includes electrical power generation, commercial space heating, and cooling and industrial process heat, and (3) describe an operational demonstration of the Fresnel lens system. The large scale Fresnel lens test article developed under an earlier version of RTOP is undergoing extensive testing and evaluation. Based on these data, the collector system will be upgraded through appropriate modifications and experiments which will simultaneously provide additional technical performance data and demonstrate application potential. Various applications will be studied and trade-off's made with other collector systems. This phase of activity will stress practical applications and is expected to lead to an operational demonstration. The sunfall monitor, also developed under this RTOP, will be used for the acquisition of solar data to determine collector performance as compared with atmospheric conditions and seasonal changes.

**W77-70727** **776-83-61**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SOLAR STIRLING EXPERIMENT**
M. E. Alper 213-354-6948

The objective of this RTOP is the demonstration of a subscale integrated solar-powered electrical power generation module utilizing a free-piston Stirling engine and linear alternator mounted on a parabolic solar collector. The free-piston Stirling engine appears ideally suited to this application because of its high efficiency, simplicity, and expected long life. Because the solar collector is the major cost element in any solar power system, the high efficiency of the Stirling engine reduces the required size of the collector and minimizes the overall system cost. Such a system has the potential to be mass produced in self-contained modules with output powers from 4 to 20Kw each with life-cycle costs expected to be competitive with current energy sources for remote locations. These systems could be used to produce electricity, pump water, etc., in locations not economical for service by utility systems. The objective for this effort is to demonstrate the compatibility of a free-piston Stirling engine with a focusing parabolic solar collector. The engine and alternator to be used could be similar to the units currently being developed under contract to the ERDA Space Nuclear Systems Division, and the parabolic solar collector is an existing unit at JPL. The demonstration module will produce approximately 1Kw electrical output.

**W77-70728** **776-90-99**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SOLAR ENERGY SYSTEMS STUDIES**
M. E. Alper 213-354-6948

The objectives are: (1) to assign detailees as requested to support the operations of the NASA Energy Program Office, Energy Technology Division in the initial definition of technical problems and the subsequent preparation of plans for their solution, and (2) to provide study support at JPL as requested by the Director of the Energy Technology Division, Energy Programs Office.

## Energy Technology Applications

**W77-70729** **778-11-02**
Ames Research Center, Moffett Field, Calif.
**HIGH-TEMPERATURE HYDROGEN ATTACK OF STEEL**
D. R. Chapman 415-965-5065
(505-01-21)

This investigation aims to define the effect of relevant high temperature gaseous environments on the integrity of pressure vessel steels used in planned and operating coal gasifiers and, if possible, to develop improved materials and/or operating procedures to increase the efficiency of gasification systems. The environments of concern consist primarily of gaseous hydrogen mixed with significant quantities of steam, CO, and CO2 and less quantities of CH4, NH3, H2S, and HCN at pressures from 15 to 1,500 psia and at temperatures from 150 to 500 C. This program will be conducted in close cooperation with the Electric Power Research Institute (EPRI) and will consist of four separate components aimed at improved efficiency (reliability) of coal gasifiers. The NASA component of the overall program will concentrate on developing improved understanding of the behavior of steels in high temperature, hydrogen rich environments with EPRI concentrating on the remaining objectives. NASA will define not only the effects of the environments (including the anticipated important effects of minor constituents) on the kinetics of relevant surface and bulk reactions, but also will define influences of these reactions on the mechanical integrity of the steel alloys. Of special interest will be the influence of alloying additions and structural modifications to the steels. The results of these

kinetics and mechanistic studies will be combined in an effort to understand and predict the rate and severity of degradation.

**W77-70730** **778-17-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**STEAM REFORMING OF NO. 2 FUEL OIL (ERDA REIMBURSABLE)**
M. E. Alper 213-354-6948

Current designs for fuel cell systems call for steam reforming of natural gas or clean liquid naptha to produce hydrogen fuel gas. The utilities would prefer to use conventional boiler fuel such as No. 2 fuel oil. The objective of this RTOP is to establish the technical feasibility of stream reforming No. 2 fuel oil.

**W77-70731** **778-30-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ADVANCED SURFACE VEHICLE SYSTEMS STUDIES**
G. W. Meisenholder 213-354-4058

The purpose of this overall RTOP is to conduct studies of the applicability of advanced technology in the modes of surface transportation. The objective of these studies is to find approaches for conserving energy and other natural resources in a matter consistent with economic, environmental and societal goals. Phase II of the effort, predicated on the results of the survey conducted in Phase I, is described. Subsequent modifications will elaborate on the complete package of studies to be performed. In Phase II, the initial effort will be documentation of the results of the Phase I survey. In addition, several tasks identified in Phase I as required to complete the analysis of the automobile/LDV mode, or necessary precursors to technology assessment of the truck/HDV mode, will be undertaken. These tasks include: (1) characterization of the requirements of special LDV fleets (taxis, emergency vehicles, RV's); (2) characterization of the trucking industry; and (3) definition of more appropriate freight modal usage and efficiency parameters. All but the latter task will be completed and reported in FY77.

**W77-70732** **778-33-01**
Hugh L. Dryden Flight Research Center, Edwards, Calif.
**AERODYNAMIC DRAG OF GROUND VEHICLES**
E. J. Saltzman 805-984-8606

Dryden Flight Research Center technology and expertise will be used to investigate means of reducing the very high aerodynamic drag of box-shaped ground vehicles (such as trucks and recreation vans) which is a factor in current and future energy problems. The coast-down technique, flow visualization techniques, pressure signature measurements, highway fuel consumption runs and other appropriate methods will be used to define, evaluate, and improve the aerodynamic efficiency of full-scale ground vehicles. Candidate modifications for full-scale testing will be derived from observations of previous full-scale results, available published data, small-scale model results and analytical and conceptual studies.

**W77-70733** **778-34-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**PLASMA IGNITION OF LEAN MIXTURES**
G. W. Meisenholder 213-354-4058

Pulsed plasma thrustor technology will be applied to the ignition system of an internal combustion engine. The heart of this system will be a concept 'spark plug' that will inject a volume of high-velocity, high-energy ionized gas into the combustion chamber to improve ignitability of lean mixtures and decrease burn time by igniting the mixture at multiple sites. Initial work has demonstrated that a pulsed plasma igniter, of a size equivalent to a conventional spark plug can be fabricated and will function satisfactorily in air. In this device the normal ignition system is used to trigger a capacitor discharge across coaxial electrodes. The small volume of gass between electrodes is ionized and brought to a very high temperature in the presence of the high energy pulsed discharge. The ionized gases are accelerated along the axis of the electrodes by JXB forces. In an engine the ignited volume will be driven into the combustion chamber at supersonic speeds to ignite the lean mixtures which will improve fuel economy and reduce exhaust emissions.

**W77-70734** **778-34-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**AUTOMOTIVE APPLICATIONS OF MICROELECTRONIC SYSTEMS**
G. W. Meisenholder 213-354-4058

Work completed to date on this RTOP has determined that the auto industry has moved toward implementation of microelectronic systems on-board autos, and that NASA could well supplement their efforts in the areas of sensors and dynamic modeling. Off-board applications, i.e., those functions associated with highway safety, law enforcement, vehicle licensing, etc., are being addressed by other studies. The effort proposed herein will review areas of interaction between on-board and off-board systems and define applications that would be feasible for NASA involvement.

**W77-70735** **778-34-04**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**POWERTRAIN AND VEHICULAR SYSTEMS TECHNOLOGY**
G. W. Meisenholder 213-354-4058

The objective of this RTOP is to develop and demonstrate technologies required to improve fuel economy of Otto cycle powered vehicles. This is in addition to the increase requested of industry by the President. Efforts to achieve this planned objective will be provided by the Jet Propulsion Laboratory as the coordinating center, NASA, universitities, and industry. The program consists of five tasks. The initial efforts will establish a fuel economy baseline and start an analytical study to identify options to achieve the fuel economy goal. Options include improvements in the vehicle, engine and drivetrain. The fuel economy baseline will determine how well and in what manner industry is achieving fuel economy gains with production vehicles. These data will be used in the assessment of alternative studies. Systems analysis and tradeoff and integration studies will produce a planned course of alternatives to focus on the system level objective. Hardware development is an important aspect of this program. This reflects the fact that achievement of the system level fuel economy objective can only occur as a result of advances at the component or subsystem level. A thoroughly characterized and controlled test vehicle will be designed and used to define each component's contribution to the system performance. Final experimental activity will provide system level data using an advanced vehicle by which achievement of the program objective can be measured. There will be a high degree of interaction between the analytical and experimental activities. This keeps the hardware activities continuously focused on the system level fuel economy objective. This program is to be completed in six years.

**W77-70736** **778-34-05**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**IMPROVED OTTO CYCLE HIGHWAY VEHICLE SYSTEMS (REIMBURSABLE)**
G. W. Meisenholder 213-354-4058

The objective of this RTOP is to provide support for the ERDA Improved Otto Cycle Highway Vehicle Systems program. The long-range goal of that ERDA program is to develop and demonstrate the technologies which will lead to a near term (i.e. pre-1985) 30 percent improvement in fuel economy for highway vehicles which use conventional Otto cycle powerplants. During the FY76 transition quarter, JPL support will be provided to ERDA for detailed planning of the Otto cycle program.

**W77-70737** **778-35-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**STIRLING LABORATORY RESEARCH ENGINE**
G. W. Meisenholder 213-354-4058

The objective of this investigation is to initiate the effort to design a prototype laboratory research Stirling engine. Such an engine appears to be essential if a wide base of Stirling cycle understanding and technology is to be established within the United States. The breadboard engine is to be a single acting two piston model designed for maximum modularity.

**W77-70738** **778-35-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena

**STIRLING ENGINE PROGRAM/ERDA SUPPORT (REIMBURSABLE)**
G. W. Meisenholder 213-354-4058

The objective of this RTOP is to provide support for the ERDA Stirling engine program. The long-range goal of the program is to develop the underlying advanced technology base necessary for the introduction into production by 1990 of highway vehicle systems realizing the full performance, fuel economy, multiple fuel and exhaust emissions potential of Stirling engines. An intermediate goal is to show that a Stirling-powered highway vehicle based on current technology can be made price-competitive on the market by 1985. JPL support of the ERDA Stirling engine program will be (1) helping with program planning, (2) providing the project management function, and (3) providing part of the supporting research and technology. During the FY76 transition quarter, JPL support will be provided to ERDA for proposal evaluation and program planning. It is anticipated that the NASA Lewis Research Center will also provide ERDA Stirling support.

**W77-70739** **778-52-01**
Goddard Space Flight Center, Greenbelt, Md.
**MECHANICAL CAPACITOR**
H. E. Evans 301-982-5194

This task covers analysis and design of a new concept for efficient storage of kinetic energy in rotating devices that can be transferred to electrical energy. Flywheel storage of energy has been implemented since the invention of the steam engines, but because of various losses, designs to store energy in momentum wheels for later conversion to electrical energy have not proven practical. These losses are: (1) friction from sliding electrical contacts and from mechanical bearings, (2) hysteresis and eddy current losses in the motor-generator, and (3) windage losses acting on the rotating mass. Recent technical advances achieved at GSFC will be used to design a 'Mechanical Capacitor' that may prove to be economically feasible for temporary storage of electrical energy. These advances are: (1) electronic commutation to achieve motor-generator switching functions without sliding contacts, (2) magnetic bearings to support the rotating mass and eliminate the losses and lubrication problems of conventional bearings, (3) ironless armature construction to reduce the hysteresis and eddy current losses of motor-generator, and (4) operation in a near vacuum to eliminate the windage losses. The storage system could be used in conjunction with public utilities for meeting peak demands, as an emergency source, and with intermittent sources such as solar or wind energy sources.

**W77-70740** **778-60-01**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**HYDROGEN PROGRAM PLANNING AND ANALYSIS**
M. E. Alper 213-354-6948
(778-60-02; 778-60-03)

The Hydrogen Energy Systems Technology (HEST) Study conducted under this RTOP during FY 75/76 assessed the national need for hydrogen based on current uses and visible trends. A report was issued in December, 1975 and distributed widely. Subsequently, the study team developed a detailed definition and description of technological deficiencies in the areas of hydrogen production and utilization, preparing an outline of the research and technology development efforts which need to be initiated at the federal level over the next five years. A report on this activity will be ussued in April, 1976. During FY TR and FY 77 the HEST team at JPL will support the Office of Energy Programs in the preparation of research and technology development program plans, concepts and project definitions for presentation to ERDA and other responsible agencies. Areas of emphasis will include hydrogen production, materials compatibilities, handling and safety. A concept paper on a hydrogen data handbook is being developed and coordinated with ERDA.

**W77-70741** **778-90-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ENERGY SYSTEMS STUDIES**
M. E. Alper 213-354-6948
(778-40-02)

The overall technical objectives and approaches of this RTOP are as follows: (1) to provide detailees to NASA Headquarters as requested to support the operations of the NASA Energy Program Office, Energy Systems Division, in the initial definition of technical problems and the subsequent preparation of plans for their solution; and (2) to provide study support at JPL as requested by the Director of the Energy Systems Division, NASA Energy Program Office.

**W77-70742** **778-90-06**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**SYNTHESIS OF RECENT ADVANCES IN GEOTHERMAL ENERGY TECHNOLOGIES (REIMBURSABLE)**
M. E. Alper 213-354-6948

Jet Propulsion Laboratory will review and synthesize five years of geothermal energy research findings obtained under NSF sponsorship. The product will be a single volumn digest of 70-100 research reports and technical publications describing the research results of NSF projects and interpreting these results in a framework of the current state of knowledge in geothermal science and engineering. The purpose of the document is to provide the geothermal industry and the research community with a concise, integrated reference manual of emerging technological advances in terms of geothermal energy utilization needs. The study will be performed in the following sequence: (1) finalize format and organization of the digest, (2) establish relevancy criteria, (3) categorize assembly documents by research topic(s), (4) review, extract, and synthesize significant finds, (5) prepare the technical digest, (6) review by study team, authors, and consultants (7) revise draft, (8) review by NSF/review pannel, (9) prepare final manuscript, (10) formulate distribution list, and (11) deliver distribution list and camera-ready copy of the manuscript to the NSF.

**W77-70743** **778-91-02**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**DEUTERIUM FUEL INJECTOR IN SUPPORT OF CONTROLLED THERMONUCLEAR REACTOR PROGRAM**
M. E. Alper 213-354-6948
(506-22-43)

The objective of this RTOP is to demonstrate feasibility of applying the NASA-developed ion thruster technology to obtain design concepts for deuterium beam injectors for ERDA's controlled thermonuclear reactor program. It appears that much of the NASA developed technology in the electric propulsion program is adaptable to these devices. In the ERDA controlled thermonuclear reactor program one approach for injecting the deuterium fuel and heating the plasma to the temperatures required involves injection of a high-energy, high-intensity neutral deuterium beam into a magnetic containment machine. For example, Lawrence Livermore Laboratory presently operates sources which deliver about 50 A at 20 kV in 2 ms pulses. The ERDA schedule calls for stepwise increase in beam energy levels and duration, eventually reaching steady state operation. The neutral beams are presently produced primarily from positive ion beams, but extension of that technique to the higher energies appears impossible. Instead, forming negative ions and accelerating them electrostatically and then stripping the electrons appears to be a possible way to form the neutral beam with the required energy. A development effort along these lines is underway at ERDA centers. It appears important for NASA to support ERDA in this important program to utilize much of the technology developed by NASA during the past decade. The effort under this RTOP will include investigation of new approach to negative beam formulation utilizing low-work-function emitter materials and surface ionization configurations. LeRC will also provide complementary supporting work in this effort.

# OFFICE OF SPACE FLIGHT

## Advanced Development LSS

**W77-70744** **907-05-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**SUPPORTING TECHNOLOGY FOR LIFE SUPPORT SYSTEMS AND CREW EQUIPMENT**
W. W. Guy 713-483-4931

The restricted Shuttle Program budget has shaped the prime contract in a manner which offers a significant opportunity for the judicious expenditure of RTOP funding. The current baseline environmental control and life support system for the orbiter uses only technology which has been proven by previous flight programs, and deemphasized growth potential for the sake of minimum weight. Furthermore, severe budget constraints during FY75 and 76 have resulted in the elimination of essentially all development testing, particularly on a systems level. The development areas described in this RTOP will fill the void created and provide a beneficial focus, with an immediate payoff, for a portion of the 907 program by: (1) developments to support baseline orbiter EVA systems design (specifically thermal and pressure protection for the EVA rescue of a Shuttle crewman) which will result in hardware developed and tested to a degree that it can be incorporated into the Shuttle program with minimum cost and program risk; (2) developments to enhance mission duration and flexibility (specifically regenerative carbon dioxide adsorber) which have demonstrated acceptable performance and interfaces for the Shuttle to a sufficient degree to implement them during the operational flights; (3) system improvements to enhance the long life, multiple use of the orbiter (such as vibration detection for component health); and (4) systems testing to evaluate component and subsystem designs (in their intended application) to obtain system level performance verification prior to committing to the designs in the flight program. This function will be performed in the Representative Shuttle ECS test bed existing at JSC.

**W77-70745** **907-06-00**
Marshall Space Flight Center, Huntsville, Ala.
**LIFE SUPPORT ENGINEERING**
J. W. Littles 205-453-3628

The objective of this RTOP is to provide the technology required for development of regenerative life support systems, specifically in the area of cabin atmosphere regeneration. Two tasks are involved: 1) HDC/BOSCH/Water Electrolysis System Integration; and 2) Trace Contamination Control. The first task will integrate hardware for regeneration of CO2 to O2, and the second will remove such trace contaminants as CO from the cabin atmosphere. Concepts will be established and hardware designed, built and tested with a view of eventual orbital flight evaluation. It is expected that the FY 77 effort will provide the design for controls and equipment for transient testing of the HDC/BOSCH system for anticipated space station conditions. Data evaluation and identification of additional verification requirements will be accomplished for the trace contamination task.

**W77-70746** **907-06-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**REGENERATIVE LIFE SUPPORT SUBSYSTEMS DEVELOPMENT**
F. H. Samonski, Jr. 713-483-5536

The basic objective of this RTOP is to develop selected regenerative life support subsystems which can be grouped in two broad categories. The first and foremost category involves preprototype hardware which will support the preliminary design phase of the RLSE (Regenerative Life Support Evaluation) Program defined by RTOP 907-44-07. Specific hardware developments being pursued to support the RLSE Program provide the functions of: (1) urine and wash water reclamation, (2) water quality monitoring, (3) water iodination, (4) oxygen generation, (5) carbon dioxide collection and reduction, (6) trace contaminant control, and (7) crew hand washing. The approach for developing the preprototype equipment involves individual contracts for the subsystem hardware. The contracts provide effort to allow each sybsystem vendor to coordinate with the RLSE integration study contractor in order to remain compatible with RLSE system integration requirements. Hardware in the second development category will receive less emphasis during the next 2 years because it involves advanced concepts that lack the technological maturity of the aforementioned RLSE subsystems. Developments to be pursued are: (1) hydrazine electrolysis for O2/N2 generation, (2) wet oxidation for waste reclamation, (3) urine electrolytical pretreatment, and (4) wash water pretreatment.

**W77-70747** **907-07-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**REGENERATIVE LIFE SUPPORT INTEGRATION AND TEST**
F. H. Samonski, Jr. 713-483-2171

The weight of the basic life support needs, such as water and oxygen is a direct function of mission duration for all the established inventory of flight-qualified, nonregenerable life support hardware. These current nonregenerable designs represent significant mission penalties for long-duration manned missions (e.g., Skylab carried about 7,000 lbs of water). Consequently, the achievement of a reliable regenerative-class life support system (LSS) is among the most significant technology areas requiring additional development for long-term space missions. Long-term, manned, earth-based tests of regenerative processes have been completed successfully, thus demonstrating a firm technology base and its potential for application. However, because the effects of a weightless environment upon the performance of such a LSS cannot be determined with certainty from earth-based tests, a regenerative-class LSS space flight evaluation is a necessay step in completing the certification of these processes and techniques. End products of the program encompassed by this RTOP will be the completion of a preliminary design for a flight evaluation on Spacelab and an integrated system ground test program at NASA-JSC utilizing preprototype subsystems developed under RTOP 907-44-06. This preprototype hardware will be compatible in function with integration requirements of a spacelab. The ground test program results will demonstrate that: (1) regenerative life support processes have achieved a state of technology readiness capable of providing the functions necessary for reliable support of man during future long-term space missions such as Space Station, and (2) the follow-on program which will yield the actual RLSE flight demonstration hardware can be initiated with high confidence.

**W77-70748** **907-38-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**LIFE SUPPORT MATERIALS DEVELOPMENT**
W. W. Guy 713-483-4931

This RTOP will result in the development of a variety of materials for EMU applications. The development of a transparent, hard, scratch and abrasion resistant coating for the existing polycarbonate space suit visor is the objective of one of the programs. Also a variety of adhesive systems which are required to support fabrication of various EVA components will be developed. These adhesives must meet many stringent requirements which include high strength, flame-resistance, flexibility, and high and low temperature resistance. An improved engineering plastic shall be developed. It should possess the following properties: high use temperature and nonflammable, low density and high strength. Lastly, the several generic classes of flame-resistance elastomeric formulations developed previously will be investigated for their ability to meet requirements of the various end use forms.

**W77-70749** **907-41-00**
Marshall Space Flight Center, Huntsville, Ala.
**MAN-SYSTEMS-VEHICLE INTEGRATION**
J. D. Johnston 205-453-3447
(970-63-10; 970-23-20; 970-83-20; 970-53-20)

The general objective to develop the capability for the augmentation of man's performance of this research is in space systems through the application of manipulator systems, sensors and actuators for earth orbital and scientific teleoperators. Specific objectives are to identify requirements and baseline systems; to develop conceptual and prototype designs and breadboards; to determine the machine's and man's roles in the operation of teleoperators and to establish their feasibility in space application to spacecraft servicing and structure assembly. Through technical studies we will identify the scientific and operational mission requirements and develop the resultant RMS and teleoperator functions. From the implied capability requirements for man and machine, the necessary technology developments for teleoperator systems and subsystems will be

derived. Required developments will be defined and implemented analytically and/or experimentally using simulation techniques, breadboard setups or prototype equipment. These studies will give insight into the functions to be performed by man or machine or both for remote explorations and operations. Function allocations will be made between man and machine for various operational requirements.

**W77-70750** **907-41-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**MAN-SYSTEMS-VEHICLE INTEGRATION**
C. E. Whitsett 713-483-4726

The exploitation of space will require the erection and utilization of large space structures. Although the role of man in this endeavor has not yet been defined, man's participation is essential. The objective of this RTOP is to define concepts which will be used for manned orbital construction and to develop requirements for equipment which will be used to fabricate and service large space structures. This orbital construction and servicing equipment (OCSE) should have potential application for any program requiring construction, assembly or servicing of a large orbital system. An area of specific emphasis in the study phase of this program will be the definition of OCSE on-orbit translation requirements. The second phase of the program will select and procure prototypes of promising OCSE concepts, with subsequent ground based tests and 0-g simulations utilizing the prototypes. The requirements for on-orbit translation will be extrapolated into a technology program aimed at improving baseline Shuttle MMU capability to accommodate the orbital construction and servicing requirements.

## Advanced Development

**W77-70751** **910-01-00**
Marshall Space Flight Center, Huntsville, Ala.
**STRUCTURES**
E. E. Engler 205-453-3958

The general objective of this RTOP is to provide technology and development data for structures to be utilized on future space transportation systems, such as single stage to orbit, heavy lift launch vehicle, orbital transfer stages and others. Special attention is focused on the utilization of advanced composite materials and related fabrication techniques and establishing realistic weight and cost data for conceptualizing these systems. In the area of advanced composites, a lightweight shell was selected for a demonstration hardware program. It will provide, through fabrication and test, realistic performance, weight and cost data for application of composites. The other aspect is to develop a computer program to establish weight and cost data for structural subsystems to be utilized in concept design and evaluation of future vehicle systems. It will incorporate the latest information on materials, design concepts, and fabrication methods. Through fabrication and testing of a large structure, nearly full scale representative of an unpressurized external shell, the viability of selected materials, design, analysis, and fabrication techniques will be demonstrated. The selected structure will have all required attachments, and weights derived from test hardware will give realistic data for future cryogenic space transportation upper stage and orbital transfer vehicles. Development of a computer system and related data base will be performed and users manuals and orientation provided.

**W77-70752** **910-02-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**THERMAL CONTROL**
W. E. Ellis 713-483-4941

The primary means for rejecting heat from current manned spacecraft while on-orbit has been through a space radiator system which is mounted on the skin of the vehicle and which rejects heat from a fluid circulating through it by radiation to the space environment. The primary goal of this activity is to develop a radiator system which is not integral with the spacecraft skin, and thus can be separately developed and manufactured. The independent development approach has significant potential to reduce spacecraft development costs by (1) reducing development and qualification testing, (2) providing a longer production run, (3) simplifying integration between the heat rejection system and vehicle, and (4) reusing heat rejection systems which are returned from orbit on other experiments. This activity has applicability to a very broad range of future possible missions, and could result in significant overall cost savings during spacecraft development and operations. Two separate advanced space radiator concepts will be pursued in an integrated effort to develop multi-mission use, low-cost heat rejection systems which can overcome the limitations of current radiator systems. These concepts are not considered to be competitive alternatives, but unique design approaches which have the combined capability to meet a wide range of specific advanced mission requirements at minimum costs.

**W77-70753** **910-02-00**
Marshall Space Flight Center, Huntsville, Ala.
**THERMAL CONTROL**
J. L. Vaniman 205-453-1171

Space Station and space transportation system thermal control is the maintenance of thermally sensitive equipment and structures within specified critical temperature limits through the control of heat flow to and from such equipment. Equipment includes (but is not limited to) such items as electronic components, optical sensors, fuel cells, batteries, APS systems, and hydraulic systems. Studies show that sophisticated semi-passive thermal control methods which require state-of-the-art advancements are required to maintain satisfactory thermal conditions for long duration under the environmental extremes encountered by those future systems. The objective of this continuing effort is to analyze, design, and develop thermal control systems (including hardware) and demonstrate system application and feasibility for maintaining thermally critical hardware within specified thermal limits.

**W77-70754** **910-03-00**
Marshall Space Flight Center, Huntsville, Ala.
**PROPULSION**
R. J. Richmond 205-453-0709

This RTOP consists of two tasks: (1) Space Shuttle Main Engine (SSME) Capability Extension, and (2) Advanced Propulsion Systems Studies. Technology will be identified and acquired to form the basis for increasing SSME specific impulse, reducing weight, increasing operational flexibility, extending engine life, and reducing maintenance cost. Advanced propulsion systems data will be developed for new propulsion systems in support of Advanced Transportation System vehicles. A SSME systems study will be initiated with the SSME developer to identify engine improvements and the required technology, and to develop the technology base. Advanced propulsion system studies will be initiated with engine developers to develop weight, envelope, and performance data; to analyze candidate engine cycles and configurations; to conduct engine/vehicle optimization studies; and to identify technology needs.

**W77-70755** **910-03-02**
Lewis Research Center, Cleveland, Ohio.
**PROPULSION-LO2 TURBOPUMP DEMONSTRATION TESTS**
John W. Gregory 216-433-4000
(506-21-11; 790-40-12)

This project aims to provide improvements in the technology of components for advanced high performance reusable rocket engines. The work is directed toward both conventional bell nozzle engines and linear/aerospike (plug nozzle) engines for advanced space transportation systems, including orbit transfer vehicles (OTV), single-stage-to-orbit (SSTO) shuttles, Space Shuttle growth or improvement, and heavy lift launch vehicles (HLLV). Included in this program are efforts on components such as: long life seals for liquid oxygen turbopumps, complete turbopump assemblies, aerospike thrust chambers, and split combustor segments of linear/aerospike chambers.

**W77-70756** **910-03-06**
Lyndon B. Johnson Space Center, Houston, Tex.
**PROPULSION**
Mark C. Buchanan 713-483-5495

The objective is to make a flightweight and size gauging system, using the ultrasonic flowmeter concept for use with N204 or MMH propellants, whichever is determined to be the worst case. The existing contract final report will be reviewed and assessed. A new two (2) year schedule will be made to design, manufacture and test a new flightweight and size gauging system. It is hoped that it could eventually be tested with the OMS (Orbital Maneuvering Subsystem) and/or the RCS (Reaction Control Subsystem).

**W77-70757** **910-04-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**ATTITUDE CONTROL PROPULSION**
Dale L. Connelly 713-483-3851

The objectives of this task are to design, fabricate, and demonstrate an advanced surface tension acquisition device for use with earth storage propellants, in spherical tanks of moderate size (25 cu ft) and for on-orbit, low-g, or high-g use in a variety of attitudes. The program objectives will be achieved in three phases. Phase I will be an analysis and design phase, including tests of key acquisition system subcomponents. Phase II will be design refinement, and fabrication and test of a full-scale tank under simulated on-orbit, low-g, and high-g conditions. Phase III will consist of an on-orbit experimental demonstration of tank performance as a Shuttle flight experiment.

**W77-70758** **910-04-00**
Marshall Space Flight Center, Huntsville, Ala.
**ATTITUDE CONTROL PROPULSION**
Francisco F. Garcia 205-453-1242

This effort will evaluate the increased service life of an improved monopropellant hydrazine N2H4 thruster and an acquisition system employing a surface tension device. A hydrazine thruster for an Attitude Control Propulsion System (ACPS) based on the radial flow catalyst bed technology developed for the Space Shuttle APU gas generator will be designed, fabricated, and tested.

**W77-70759** **910-04-03**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**ATTITUDE CONTROL PROPULSION**
P. J. Meeks 213-354-2546

The objective of this work is to investigate propellant substitutions as a means of reducing the recurring costs associated with the shuttle. During FY-TR and -77, JPL will (1) continue, in conjunction with JSC, the design studies relating to the substitution of hydrazine N2H4 for monomethylhydrazine (MMH) in the Reaction Control and Orbital Maneuvering System on-board the Space Shuttle, (2) continue the contracted experimental effort to adapt the RCS main engine to the use of N2H4/N2O4 instead of MNH/N2O4, (3) initiate a contracted design study to modify the OMS engine to operate with N2H4/N2O4 in place of MMH/N2O4, and (4) initiate a brief investigation of alternate nozzle concepts for the RCS and vernier thrusters to reduce plume effects.

**W77-70760** **910-05-00**
Marshall Space Flight Center, Huntsville, Ala.
**ELECTRICAL POWER**
J. L. Miller 205-453-2113

The objectives of the RTOP are to develop essential technology, design requirements, and design specifications and to perform component research and breadboard/prototype development necessary to produce flight qualified hardware for long life, cost effective power systems. The following tasks will be performed: (1) Power Conditioning will develop standardized power conditioning circuits and equipment in which built-in test, system monitoring and control, and advanced concepts will be investigated; (2) Lightweight Fuel Cell will develop a 15 lb/KW fuel cell which uses propellant grade reactants; (3) Backup Fuel Cell will evaluate Shuttle fuel cell hardware for use with propellant grade reactants; (4) Photovoltaic/Electrolysis Fuel Cell Power System will characterize a Space Station power system which can be five times lighter than batteries; (5) Nickel Hydrogen Batteries will evaluate lightweight secondary batteries for low-earth orbit; and (6) Thermophotovoltaic Power Source will evaluate thermophotovoltaic techniques for high concentrations of solar energy.

**W77-70761** **910-05-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**ELECTRICAL POWER**
G. D. Hydrick 713-483-6491

The objective of this program to capitalize on proven technology and provide further advancements to establish a highly efficient, low cost, long lived, versatile fuel cell base with adaptability to meet changing and varied application requirements. Controlled laboratory tests of sub-scale hardware and full scale reactor stacks in the Solid Polymer Electrolyte (SPE) technology will be applied in this program with emphasis on the basic element (cell) of the fuel cell reactor. Controlled parametric tests and evaluations of techniques, materials and design will be accomplished to identify and reduce to practice those improvements translatable to operational systems. The program will be conducted in a phased manner to provide a normal progression to higher levels of demonstration as the technology progresses.

**W77-70762** **910-07-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**SPACE COMMUNICATIONS AND TRACKING**
Max Engert 713-483-2918

This RTOP provides for improved space television cameras that will be required to support future space missions. Improvements will be achieved by the application of advanced solid state electronics. In particular the application of solid state imaging devices will greatly reduce television camera size, weight, and power requirements, provide higher reliability, provide equivalent resolution to tube sensors, and reduce program cost. Additionally, this RTOP provides for the technology improvement required for increasing the RF power output of an S-band TWT amplifier.

**W77-70763** **910-07-00**
Marshall Space Flight Center, Huntsville, Ala.
**COMMUNICATIONS**
D. O. Lowrey 205-453-1578

The objective of this RTOP is to perform studies, analysis and tradeoffs of communications systems, concepts and techniques to enable the space station to meet its requirements for multiple beam communications with numerous free flyers operating within the space station control. These Systems will provide high data rate communications, command control, tracking, rendezvous and docking along with visual systems capability. A continuation of the Ku-band electronically steerable phased array will provide a major technology base and data that will be utilized in the performance of all remaining tasks described in the RTOP. In-house efforts, in parallel with contractual studies and development, will be utilized to accomplish the RTOP. Results and data Exchanges will be made available on a routine basis for use in the space station development program.

**W77-70764** **910-07-06**
John F. Kennedy Space Center, Cocoa Beach, Fla.
**FIELD TEST OF FIBER OPTICS CABLE**
C. H. Bell 305-823-3842

The objective of this effort is to demonstrate the installation, operation, and maintenance of a wideband fiber optic cable transmission system. Field tests will be conducted at KSC in an operational environment in order to determine and define the installation and maintenance requirements for such a system.

**W77-70765** **910-08-00**
Marshall Space Flight Center, Huntsville, Ala.
**STABILIZATION AND CONTROL**
S. M. Seltzer 205-453-4580

Digital control design and analysis techniques will be developed and/or extended. They will be used as an aid in verifying the Spacelab Instrument Pointing System (IPS) design. Significant nonlinearities will be defined and discrete describing functions developed. Pointing performance with the IPS will be determined and requirements on payload flexibility defined. An analysis will be made of sensor and actuator placement. Control system techniques will be developed for very large structures in earth orbit. Large-scale systems modeling and analysis will be conducted. Advanced control techniques for distributed systems will be investigated and disturbance models developed. Control

system techniques will be developed to stabilize and control a large multi-unit Space Station during and after assembly in orbit and be capable of adapting to a wide range of operational control requirements. Advance control techniques will also be evaluated. The feasibility will be determined of an Integrated Power/Attitude Control System (IPACS) for the Space Station. The system would use momentum devices for attitude and stabilization control and balance the energy inserted or removed from these devices and the utilization of that energy for electrical power and supply needs, resulting in considerable cost savings.

**W77-70766** **910-08-04**
Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena
**INSTRUMENT POINTING SYSTEM TECHNOLOGY FOR SPACE LABORATORY**
R. V. Powell 213-354-6586
(506-19-14; 975-40-11)

The Instrument Pointing System (IPS) being developed by ESA for Spacelab must accommodate a wide variety of earth, solar and astronomy payload requirements. A high precision pointing system is required for orientation and control of the onboard scientific instruments. The utilization of the Low Cost Systems Office (LCSO) components and near-term-ready OAST sponsored control system technologies can provide a cost effective approach in the further development of the IPS. The objective of this effort is to ensure the effective integration of the applicable LCSO components and advanced development technologies into the IPS development. The emphasis during FY77 will be on examining the effective utilization of present and near-term available LCSO and advanced technology components and techniques which may result in cost savings and additional performance in the IPS. In addition, commonality of devices required for other experiment pointing systems will be evaluated. A programmable systems approach to accommodate a broad range of payload differences without significant modifications to the devices will also be examined. IPS simulation models developed in FY76 will be updated using new candidate devices. A final report will be prepared on simulation results and recommended device applications to IPS to satisfy future requirements through a more cost effective approach.

**W77-70767** **910-09-01**
John F. Kennedy Space Center, Cocoa Beach, Fla.
**(HYPERGOLICS DISPOSAL)**
H. Franks 305-823-2758

The disposal of hypergolic liquids and vapors at KSC in such a way as to minimize effluent effects on the environment is a project that is continuing, based on criteria developed under contract NAS10-8399, 'Hypergolic Propellants Liquid and Vapor Disposal.' Activities will include the evaluation of dry chemical reaction and bed absorption scrubbing concepts and investigate vortex cooling and centrifugal separation of gas streams to remove hypergol vapor. These technologies have indicated considerable promise during current research work under this task.

**W77-70768** **910-10-00**
Marshall Space Flight Center, Huntsville, Ala.
**GUIDANCE AND NAVIGATION**
B. F. Walls 205-453-5910

This RTOP describes the program of research and technology develoment in guidance and navigation planned to establish an adequate technology base for the design and development of High Performance Upper Stages and Space Stations. The objective of this effort is to provide advances in the state-of-the-art in the inertial measurement unit and the scanning laser radar sufficient to support the design and development of High Performance Upper Stages and Space Stations. The approach is the in-house performance of specific improvements in operational characteristics, weight, cost and reliability of the guidance and navigation systems and components. This program takes advantage of other ongoing development programs at MSFC, such as SUMC computer funded by OSF and the laser gyro funded by OAST.

**W77-70769** **910-13-00**
John F. Kennedy Space Center, Cocoa Beach, Fla.
**INSTRUMENTATION**
P. D. Toft 305-823-2780

The objective of this project is to provide instrumentation to support KSC launch operations. The automation of minor chemical analytical instrumentation processes is desired to reduce the manpower required, to increase proficiency, and optimize processing equipment requirements to support microchemical sample analyses. The development of signature and modal analysis techniques for malfunction investigations will reduce O&M requirements for GSE equipment at KSC. Development of a simple inexpensive HCL dosage indicating device for field use is needed by KSC to monitor environmental impact.

**W77-70770** **910-13-00**
Marshall Space Flight Center, Huntsville, Ala.
**ADVANCED INSTRUMENTATION**
Donald R. Wilkes 205-453-2405
(750-01-71)

The objectives of this RTOP are: (1) to complete the development of the advanced second generation contamination measuring instrumentation required to complete the contamination assessment for the Space Transportation Systems, (2) to define and develop methods and instrumentation required for in-orbit servicing of thermal control surfaces, (3) to determine the effects of the space station environment on thermal control surfaces, and (4) to define radiation hazards, possible protective measures and monitoring instrumentation for solar flares, trapped belt, and cosmic ray particles on the synchronous orbit space station. These objectives are to be accomplished under three tasks: (1) Advanced Instrumentation (Contamination), (2) Space Station Thermal Control, and (3) Radiation Hazards and Protection.

**W77-70771** **910-13-03**
Lyndon B. Johnson Space Center, Houston, Tex.
**DATA ACQUISITION AND CONTROL SYSTEM FOR SCIENTIFIC SHUTTLE SORTIE PAYLOADS**
R. D. Eandi 713-483-4757

The objective is to develop a common data acquisition and control system for shuttle sortie payloads. The objective will be accomplished by investigating the application of existing ground-based laboratory equipment and standardization concepts to shuttle sortie research payloads that involve a wide variety of electronic equipment requirements. The current Nuclear Instrumentation Module (NIM) and CAMAC standards for modular electronic equipment will be reviewed and analyzed from the standpoint of applicability to Shuttle Sortie experiment operations. Required additions and modifications to the current standards will be identified. The electronic system requirements of representative payloads will be analyzed with respect to applicability of NIM and CAMAC-like standardization concepts, and an electronic system design incorporating standardized equipment modules will be performed. The results of the studies of the individual payloads will be compiled and assessed to: (1) establish the degree of commonality that can be obtained with the application of the standardized modular equipment concept, and (2) determine the cost effectiveness of adopting a standardized modular equipment concept.

**W77-70772** **910-13-14**
Lyndon B. Johnson Space Center, Houston, Tex.
**FIBER OPTICS INSTRUMENTATION FOR OXIDIZER TANKS**
A. W. Wardell 713-483-3958

Design, construct, and demonstrate operation of a preliminary fiber optics instrumentation system suitable for use in oxidizer tanks of future spacecraft programs. The measurements required will include liquid point level sensing, temperature, and pressure. The system(s) proposed must be compatible with oxidizers such as liquid oxygen and nitrogen tetroxide, and must function in typical ground and flight environments such as those defined in JSC 07700, Volume X, 'Space Shuttle Flight and Ground System Specification,' Appendix 10.11, 'Induced Environment Design Requirements.'

**W77-70773** **910-21-00**
John F. Kennedy Space Center, Cocoa Beach, Fla.

**MANUFACTURING AND INSPECTION**
C. L. Dillon 305-823-3540

The objective of this project is to improve the capability of KSC to utilize and interpret X-ray and N-ray photography obtained at KSC for inspection and test purposes on a wide variety of mechanical, structural and electronic components.

**W77-70774** **910-21-00**
Marshall Space Flight Center, Huntsville, Ala.
**MANUFACTURING AND INSPECTION**
R. L. Kurtz 205-453-0941

The objectives of this RTOP are: (1) to perform the necessary basic and applied research to continue upgrading the manufacturing and materials non-destructive testing techniques and systems emphasizing holography, (2) to provide a prototype hardware system which is a hybrid combination of several holographic techniques with the capability for on-site inspection of thin wall tank structures and composite materials including near real time automatic data acquisition and analysis, (3) to produce an advanced ultrasonic test system, and (4) to develop upgraded feasible limits and guidelines for contamination control in flight systems fabrication. These new technology goals will result in increased productivity, reduced costs, and will maintain essential areas of in-house technical competency. These objectives will be met through the pursuance and implementation of the following tasks: (1) Holographic Theoretical Model Development, (2) Basic Developments in Holographic Detection, (3) Composite Mobile Holographic Nondestructive Testing (CMHNDT) System, (4) Acousto-Optical Holographic Nondestructive Testing (AO-HNDT) Systems, (5) Automated Holometry Fringes Inspection and Data Analysis, and (6) Advancement of Automated Ultrasonic Testing.

**W77-70775** **910-26-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**DEMONSTRATION OF PRODUCTION APPLICATION OF ADVANCED ORBITAL PROPAGATION TECHNIQUES**
G. Weisskopf 713-483-4346

The objective of this RTOP is to continue the testing and evaluation of new orbital trajectory propagation methods in order to determine their applicability to production application. Over the last several years new formulations of the basic equations of celestial mechanics have been developed. These new formulations permit both analytical and numerical computation of satellite orbits which are very rapid, accurate, and stable for long term propagation. The new formulations being investigated are mainly: elements based on Kustaanheimo-Stiefel (KS) theory; and elements similar to the classical Delauney elements (DS), the Pioncere' elements (PS), and Oblateness elements (OB). The objectives to be accomplished under this RTOP are: (1) continuation of the current effort to evaluate the applicability of these new formulations to existing and future mission planning and flight design programs, (2) expansion of the current effort of testing and documenting these new formulations to include force models and numerical integrators; and (3) expansion of the current effort to include investigation into applicability of new propagation methods to the area of shuttle upper stage flight design and analysis problems.

**W77-70776** **910-27-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**DEVELOPMENT OF AN INTERACTIVE COMPUTER PROGRAM TO PROVIDE SOFTWARE STRUCTURE ANALYSIS AND TEST DATA DESIGN AID**
M. A. Goodwin 713-483-4751

The objective of this task is to continue the development of an interactive computer program which increases the efficiency and effectiveness with which a unit of software code can be verified. The basic technique utilized is that of statically analyzing a unit of code which a programmer is developing computing paths through that code, and outputting sufficient information for the user to use to construct data which cause these paths to be executed. It constructs the fewest paths that include all the code. A unit test drive now in development, interfaces interactively with the user and allows him to actually execute the unit independent of the system to which it belongs but considering the effect of interfaces. In addition, the program outputs errors that are path-dependent and cannot be detected by a compiler. The program operates on the UNIVAC 1110 EXEC VIII system on FORTRAN V code.

**W77-70777** **910-27-02**
Lyndon B. Johnson Space Center, Houston, Tex.
**DEVELOPMENT OF MISSION DESIGN TOOLS USING LINEAR TRANSFORMATION ORBIT THEORY**
Victor R. Bond 713-483-4581

The Delaunay and Poincare-Similar (DS and PS elements) orbital elements that were formulated and/or developed under previous RTOP will be applied in the investigation and solution to the following problems: (1) analytical solutions will be developed and programmed for 'geosynchronous' orbits perturbed by both gravitational forces and solar radiation pressure, (2) analytical solutions for transfer orbits from earth to other planetary orbits as well as from near earth to elliptical orbits will be formulated, (3) the relative motion of one satellite with respect to another will be investigated by a Hamiltonian mechanics approach in order to systematically develop a set of elements of the motion, and (4) the drag problem in the PS phi elements will be further investigated to include the higher gravitational harmonics.

**W77-70778** **910-27-03**
Lyndon B. Johnson Space Center, Houston, Tex.
**RELATIVE MOTION ANALYSIS OF DEPLOYMENT/RETRIEVAL OF PAYLOADS**
R. E. McAdams 713-483-4491

The objectives to provide extensive model addition to an existing 6-DOF digital simulation to provide a capability to analyze Orbiter payload deployment and retrieval within the constraints dictated by payload requirements, as well as orbiter and deployment/retrieval systems capabilities. The modification will be consistent with the requirements to incorporate the contamination and over pressure environments expected to be derived from RTOP 975-40-01-63. This task entails the model addition to an existing 6-DOF digital computer simulation by incorporating existing models such as the RMS, PIDA, contamination overpressure environment models, etc., to provide a capability to combine the orbiter, deployment/retrieval devices, and payload into a single simulation. This will provide a method to assess the rotational and translational dynamical effects of the combination (orbiter, deployment/retrieval systems, and payloads) or on individual elements when exposed to the contamination overpressure environment within the systems constraints of each. In addition, this modified simulation provides a capability to perform a detailed relative motion analysis and to define the stability characteristics of the orbiter as well as the payload. The basic approach will be to gather and modify existing models to provide additional capability to the existing 6-DOF multi-vehicle digital simulation program.

**W77-70779** **910-27-04**
Lyndon B. Johnson Space Center, Houston, Tex.
**ADVANCED FLIGHT DESIGN TECHNIQUES**
E. C. Lineberry 713-483-5276

This task involves conceptual development and feasibility studies of executive control logic (MDEX) for an advanced flight design system. The logic will provide overall control for the flight design system, and will provide interactive assistance to the user of the system. This includes modules sequencing for interactive analysis prompting, initialization control for batch processing, database interface, automated documentation interface control, and graphics interface control. Support will be provided to investigate current analysis program software to increase the overall speed of execution. This support will include restructuring within existing RTOP developed modules as well as making recommendations relative to the redefinition of modules for the solution of analysis tasks. Support will be provided for integration assistance in the overall development of the flight design system. This integration activity includes MDEX, the database, the interactive operating mode, the batch operation mode, graphics, and automated documentation.

**W77-70780** **910-27-05**
Lyndon B. Johnson Space Center, Houston, Tex.
**RUNGE-KUTTA NUMERICAL INTEGRATION DEVELOPMENT AND ANALYSIS**
Victor R. Bond 713-483-4581

The overall objective of this study is to develop improvements in the Runge-Kutta method of numerical integration in order to increase the accuracy of results and reduce computation time. These improvements include formulating higher order algorithms than now exist and developing a strategy to provide a variable-step-variable-order Runge-Kutta algorithm. The higher order algorithms will be developed according to the method of Fehlberg. Imbedded in Runge-Kutta algorithms often are algorithms of lower order. The variable-step-variable-order algorithms will make use of this fact as part of the strategy for producing a reliable solution with a minimum of computing time. Another phase of the task will investigate long term stability of numerical integration.

**W77-70781** **910-27-06**
Lyndon B. Johnson Space Center, Houston, Tex.
**OPTIMIZATION APPLICATIONS IN GUIDANCE AND FILTER GAIN DETERMINATION**
B. R. Uzzell 713-483-3532

Selection of guidance system gains to minimize deviations from a nominal trajectory, and navigation filter gains to minimize errors in the estimated state, usually involves two separate efforts. There appears, however, to be some interaction between the two selection processes. The goal of this research is to study the interaction of the guidance and navigation systems especially in the critical flight region from 270,000 feet altitude down to 135,000 feet. The study should show how the choice of feedback guidance gains affects the accuracy of the state estimate by the navigation filter and develop insight into how the pseudo-drag measurement should be treated (i.e., open loop or filtered). In addition a general computer program for the determination of gains (constant or time, range, or velocity varying, as specified by the investigator) which minimize appropriate performance measures for guidance and navigation should be developed.

**W77-70782** **910-28-00**
Marshall Space Flight Center, Huntsville, Ala.
**SOFTWARE PROCESSES**
B. C. Hodges 205-453-0134

The objective of this effort is the development of techniques and algorithms for the automatic verification/validation of software modules. FY-75 effort placed emphasis on analysis of existing techniques and design of a unified system approach to software testing. FY-76 efforts are directed toward the implementation of the techniques. FY-77 efforts will be applied to application, testing and modification of the critical Software Specification and Evaluation System (SSES). This total RTOP effort will provide new capabilities for reducing total software testing time without sacrificing confidence in performance, and at the same time improve the cost ratio between hardware/software systems.

**W77-70783** **910-28-04**
Lyndon B. Johnson Space Center, Houston, Tex.
**SYMBOLIC ALGEBRAIC MANIPULATION APPLICATIONS**
R. Rosencranz 713-483-3217

This RTOP seeks to provide contribution of JSC share of MACSYMA consortium managed by Langley Research Center. Experimental and production usage of the MACSYMA capability will be employed to increase JSC knowledge of the system, its usability and cost-effectiveness as well as to contribute to overall development objectives of the MACSYMA project, a 3-year effort starting in FY76. Advanced Development (910) RTOP funds are requested only for the JSC share of the consortium. The related JSC efforts are performed by civil servants or by contractors funded by other sources.

**W77-70784** **910-31-00**
Marshall Space Flight Center, Huntsville, Ala.
**SPACE OPERATIONS TECHNIQUES**
E. E. Engler 205-453-3958

The general objective of this RTOP is to provide a coordinated program of development for Advanced Space Technology/ Subsystems in several different areas. The areas to be studied include the following: (1) space qualified, leakproof, fluid connectors for orbiting vehicles; (2) large space structural element joints and modules for fabrication on the ground and in orbit; (3) structural members for large space structures suitable for automated space fabrication and assembly techniques; and (4) spacecraft subsystem mechanical attachment systems. The approach for this program will be to develop test hardware or systems for the above areas. These test items will be evaluated according to the requirements developed within the program.

**W77-70785** **910-31-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**CONSUMABLES MANAGEMENT FOR ADVANCED SPACECRAFT**
W. Scott 713-483-3458

The overall objective of this RTOP is to define and develop the consumables management requirements for all phases of a repetitive vehicle space program. This RTOP is directed toward development of Advanced Spacecraft consumables management techniques which do not require personnel specifically trained in consumables technology in the routine planning, crew training, and flight operation for highly repetitive vehicles. The goal is to provide a management system which will result in a saving of $35,000/flight over currently employed techniques. The best approach to satisfying the objectives is to develop a relatively automated (ground or onboard) method of processing flight data to maintain the mission planning, crew training and flight data base for the fleet and/or individual delivery spacecraft as required to support consumables subsystem maintenance, logistics, as well as reduce planning and flight dispersions. The developmental consumables management software will be modified into a more automated version which will process the flight data base for the consumables management portion of the total flight planning system.

**W77-70786** **910-31-02**
Lyndon B. Johnson Space Center, Houston, Tex.
**DEVELOPMENT OF CRYOGENICS PVT ALGORITHMS FOR SPACE APPLICATIONS**
W. Scott 713-483-3458

The objectives of this RTOP are (1) complete the slush property work that was initiated during the previous fiscal year; (2) using the new O2 data generated under Lewis Research Center funding, refit the O2 equation-of-state; (3) develop a thermophysical properties of fluids package of computer programs; (4) measure dielectric constant of slush H2; and (5) perform an RF gaging experiment on slush H2. The first two objectives will be satisfied by employing least squares statistical techniques in developing the equations-of-state for slush cryogens as well as a refit of the new O2 data. The 'fluids pack' will serve as a cryogenic data base and would be readily transferable to both government and industry users. It will be written modularly such that a user may extract a given property or subprogram and use it independently of the rest. The dielectric constant (objective 4) of slush will be measured experimentally from slush produced under a KSC RTOP to begin in October 1976. An RF gage developed under an earlier JSC RTOP will be utilized as a possible candidate for future space/industry applications. Again, utilizing the slush produced under the KSC RTOP the RF gage will be utilized to measure mass density and compared to the experimental values to determine instrumentation accuracy.

**W77-70787** **910-31-03**
Lyndon B. Johnson Space Center, Houston, Tex.
**SPACE OPERATIONS TECHNIQUES**
Frederick J. Stebbins 713-483-3576
(910-44-31)

The objective is to design an engineering structural model which is designed to possess structural similitude with a large space erectable structure. The similitude shall be such that data from the structural model may be scaled to a full sized structure similar to the satellite solar power station. The structural response (deflections, stresses, frequencies, etc.) shall be scalable through use of similitude parameters established in the detail design of the structural model. End products will be a set of detailed

structural drawings of the model complete with documented dynamic loads and stress analyses, as well as the documented similitude relationships with a large space erectable structure. Two detailed structural test programs will be developed based on the assumption of ground test only and orbital zero 'g' experiment opportunity. In addition, a 'show & tell' model of the structural model will be built for conceptual understanding of the design concept.

**W77-70788** **910-31-08**
Lyndon B. Johnson Space Center, Houston, Tex.
**ADVANCED CREW ACTIVITY PLANNING SYSTEM**
J. A. Wegener 713-483-2541

The purpose of the study is to develop advanced software techniques that provide interactive pre-mission and real time tools for the crew activity planner. The prototype planning modules developed through this study will ultimately interface with the SMCC and be utilized for the automated generation of crew activity timelines. These crew activity planning techniques are directed toward reduced costs in mission planning for the STS and for future space programs that provide service to a multidisciplined science community. The contractor will participate in the requirements definition and conceptual design studies to support the development of the crew activity planning system. The contractor will then develop and implement the software required utilizing GFE computers.

**W77-70789** **910-32-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**ADVANCED TECHNOLOGY SUBSYSTEM**
Michael K. Hendrix 713-483-4061

The objective of this development is the feasibility demonstration through thorough evaluation testing of a low cost, standardized, prototype non-volatile (information is retained if power to the device is lost) semiconductor memory. This device may be used advantageously in experiments, control systems, and particularly in data management applications where low power, small size, and high reliability are required. The memories will be designed as a standardized functional block which can be assembled into large, low cost, mass memory arrays. This development effort will be conducted in three stages: (1) a previously completed study was made to determine which microelectronic integrated circuit technology best satisfied the performance, cost, and reliability requirements consistent with the specific data storage applications. The results of this study will be used to define the design requirements for the microelectronic chip. (2) A microelectronic chip will be designed, fabricated, and tested. Key design parameters will be retention time, interrogation time, power dissipation, transient tolerance, and radiation resistance. Evaluation testing of key electronic parameters will verify performance of device and demonstrate its reliable use in higher level assemblies. (3) A microelectronic hybrid assembly (consisting of several non-volatile chips interconnected on a common substrate) will be designed, fabricated, and tested. The results of this testing will prove the feasibility of using the non-volatile microelectronic chip in spacecraft systems.

**W77-70790** **910-33-00**
Marshall Space Flight Center, Huntsville, Ala.
**INFORMATION MANAGEMENT SYSTEM (ADVANCED FLIGHT COMPUTATIONAL SYSTEM)**
J. B. White 205-453-3987
(180-17-54)

The objective of this RTOP is to direct and develop an advanced technology flight computational system capable of performing, reliably, all the functions required by a space system such as Space Station. Key technical areas to be addressed are high reliability, redundancy, maintainability, long life, flexibility, expandability, modular architecture, large main memory, large offline bulk storage memory, high system throughput, low power, and reduced software costs. The approach to be taken is cost effective since full advantage will be taken of all the spinoffs, fallouts, knowledge, and experience achieved from past and ongoing programs such as Space Station studies, the CVT program, and the Space Ultrareliable Modular computer (SUMC) program. The SUMC program is of particular significance because the internal fault tolerant memory, power supply design, SOS-CMOS technology/chip development, redundant multicomputer/processor architectures are directly applicable to the computational system needed for complex, long life systems. These proven concepts and designs will be combined and integrated with the newly defined tasks, presented in this RTOP, which are more specifically related to Space Station requirements.

**W77-70791** **910-33-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**INFORMATION SYSTEMS MANAGEMENT**
Tommie L. Wheeler 713-483-2417

This task supports activity associated with development of integrated data handling concepts and system hardware applicable to both near term and future space programs. Specific objectives include system architectural concept definitions for a universal controller, modularly expandable data acquisition systems and multiple channel decommutator systems approaches based on assessment of current and future space program needs.

**W77-70792** **910-35-02**
Langley Research Center, Langley Station, Va.
**INTEGRATED POWER/ATTITUDE CONTROL SYSTEM FOR SPACE VEHICLE APPLICATIONS**
J. E. Stitt 804-827-3745
(506-19-13)

This work will establish the required technology for an Integral Power/Attitude Control System (IPACS) capable of performing the dual function of power generation and attitude control for a large variety of spacecraft and missions. Results from in-house and contractural efforts are being used to investigate power generation and control capability of IPACS; to generate requirements for critical hardware components; to develop IPACS configurations and control laws; and to define multimission applicability of IPACS to provide low cost modularized vehicle subsystem. Viability of the IPACS concept will be verified through integration of critical hardware components into a laboratory IPACS and thorough evaluation of this unit in a realistic mission and dynamic environment using LRC static and dynamic test facilities. Associated development programs will be directly coordinated with LeRC, GSFC, JSC, and MSFC. Preliminary problem areas include the impact of reliability, maintainability, failure modes, and system integration on IPACS performance and multimission usage capability; performance limits of composite materials under cyclic stresses and extended-during vacuum; development of bearings, seals, and lubrications systems capable of long-life at high speeds and under large cyclic loads; development of high power, high-efficiency motor generator units for operation at high speeds; development of high-power, long-life, low-friction slipring assemblies for operation in a vacuum. Solutions to these problems will be verified through hardware tests and simulations, which will determine power generation capability, control effectiveness, and spinup, spindown cycling effects on system performance.

**W77-70793** **910-35-04**
Lyndon B. Johnson Space Center, Houston, Tex.
**SYSTEMS ENGINEERING APPLICATIONS**
W. F. Perlich 713-483-3238

This RTOP will provide a systems analysis and evaluation of several methods of storing and transferring propellants in orbit. Long term and short term storage and several methods of settling propellants to enable transfer will be evaluated in terms of overall systems effectiveness and desirability. Large scale operations in geosynchronous space will require the fueling of orbital transfer vehicles in low earth orbit according to current concepts. The transfer of propellant to low earth orbit and its subsequent use in the OTV's involves questions of zero-g transfer and storage that need resolution in terms of the overall systems impact. To establish the feasibility and provide practical cost effective configurations utilizing electric propulsion systems for earth orbit transfer and attitude/station maintenance. Ion, magnetoplasmadynamic (MPD), and arcjet electric propulsion system concepts are strong contenders for satisfying the dual requirement of orbit transfer and attitude control. The dual purpose electric propulsion systems could be applied to the transfer of payloads such as

satellite power stations or space station structures, modules, or supporting materials from low to geosynchronous earth orbit and for the application to long duration orbit maintenance and attitude control of on-orbit space construction assembly.

**W77-70794** **910-35-06**
Lyndon B. Johnson Space Center, Houston, Tex.
**NEW TECHNOLOGY COST ESTIMATING RELATIONSHIPS**
Humbolt C. Mandell, Jr. 713-483-4551

The objective of this RTOP is to provide JSC and NASA with an in-house capability to estimate resources for the new and advanced technologies which will be used in future space programs to assure the achievement of the low cost objectives. The study will include Advanced Propulsion Systems, Amplitron/Klystron Technologies, Space Manufacturing and Assembly, Large Scale Power Conversion Systems, and Learning Curve Theory as applied to extremely large quantities. The approach is: (1) to collect in-house and contractor data on each of the various areas of study; the data needs to include both technical and programmatic information; (2) to normalize and analyze the data, using the appropriate statistical techniques; this analysis will result in estimating relationships which allow JSC and NASA to determine manpower, costs and schedules as a function of a few driving parameters for each of the different technologies; and (3) to test the resulting relationships for engineering reasonableness and accuracy.

**W77-70795** **910-36-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**MECHANICAL SYSTEMS**
J. T. Edge 713-483-4310
(505-07-25)

The objectives of the tasks covered in this RTOP include: task 46 - Electromechanical (EM) Actuator, - development and demonstration of EM actuator technology for aerospace applications; task 71 - Servo Air Bearings - design and develop a means of servoing air bearings to cancel frictional drag as an aid in providing realistic dynamic simulations; task 72 - Orbital Assembly Docking - establish operating requirements and provide preliminary design of docking systems for joining large modules during orbital assembly; and task 73 - In Orbit Inspection and Repair Aid - develop a method by which a man can both physically and selectively restrain himself on the outside spacecraft surface for the purpose of inspection and repair. The approach is to conduct an orderly phased program approach by developing system requirements to meet the technical objectives, conducting conceptual and/or preliminary design of candidate concepts and hardware requirements, and performing detailed design and manufacture of selected scaled or full-sized hardware for in-house test and/or evaluation. A brass board redundant four-channel actuator utilizing brushless permanent magnet DC motors and solid-state current source inverters is being developed. This brass board will demonstrate feasibility and establish system design parameters on a total system basis. Redundancy management techniques will be developed and evaluated.

**W77-70796** **910-37-00**
John F. Kennedy Space Center, Cocoa Beach, Fla.
**CRYOGENICS**
W. H. Boggs 305-823-2102

One of the objectives of this project is the development of a cooling unit which will economically reduce liquid hydrogen boiloff from the large 850,000 gallon storage dewars used on KSC Launch Complex 39. The project includes the necessary engineering, design cost trades, prototype system fabrication, and testing to develop the cooling unit. Another objective will be to complete the technology base for producing and handling slush oxygen and slush hydrogen in preparation for future long space missions. This second effort will be in concept with related activities at JSC.

**W77-70797** **910-37-01**
Marshall Space Flight Center, Huntsville, Ala.
**CRYGENICS**
E. H. Hude 205-453-3626

The basic program objective is to develop a cryogenic component technology base suitable for input into realistic trade involving cryogenic propellant management subsystem options. Analytical studies, environmental parameters and component development will be combined to establish design data on performance and reusability. Operational constraints and interface design criteria will be a principal output of the subsystem and system testing. Subsystem concepts will be tested to identify system interface problem areas and assess the maintenance/cost relationship. Advanced concepts developed under prior technology programs which have not been applied to flight vehicles, but already have a hardware development history, will be utilized. Specific propellant management areas to be assessed in combined component testing include Multi-Layer Insulation (MLI) reusability, zero-g propellant acquisition, and low or zero NPSH pumping. This RTOP effort will involve the task of Cryogenic Component Interface Testing.

**W77-70798** **910-38-00**
Lyndon B. Johnson Space Center, Houston, Tex.
**MATERIALS**
F. S. Dawn 713-483-2059

This RTOP will result in the development of new spacecraft interior nonmetallic materials capable of meeting rigorous safety and performance requirements. Specifically nonmetallic materials are required which are nonburning and low smoking and low offgassing in spacecraft interior environments while exhibiting a good balance of engineering properties. Programs are specifically geared toward minimum weights through selection of low density materials, improved component design and high performance requiring minimum-thickness usage. Programs reflect high technology leverage for the most part in that they consist of combining untried but already developed materials in new usage applications resulting in substantial yields in improved product performance.

**W77-70799** **910-38-00**
Marshall Space Flight Center, Huntsville, Ala.
**MATERIALS**
J. C. Horton 205-453-1500

The objective of the effort represented by these tasks involves the development of materials, the determinatin of materials properties, space effects on materials, and the development of processes that could provide urgently needed advancements in materials technology. Advanced Space Systems will require materials that provide long life with little degradation. To accomplish these objectives, the following tasks will be continued: (1) Solid Film Lubricants and (2) Ferrofluid Bearing Lubrication Development. Additional tasks to be performed are: (1) Long Term Evaluation of Space Compatible Lubricants, (2) Evaluation of Effects of Solar Radiation on Glasses, and (3) Evaluation of Expandable Rigidized Structures.

**W77-70800** **910-39-00**
Marshall Space Flight Center, Huntsville, Ala.
**AEROTHERMODYNAMICS**
W. K. Dahm 205-453-3017

To provide engineering tools to solve some critical aerothermodynamic problems of advanced space vehicles, as basis for feasibility and design studies, the following tasks will be performed: (1) Fuel Dumping and Liquid Waste Discharge at High Orbital Altitudes. An engineering model will be established for predicting characteristics of liquid discharge plumes (propellants, liquid wastes). The model is to cover factors such as particle size and velocity spectra, extent of supercooled range, effects of mass flow rate, and vapor pressure. (2) Water Impact of Heavy Lift Launch Vehicle (HLLV). Study will be made of how extensively the use of retrojets alleviates water impact loads of ballistically recovered HLLV. (3) Aerodynamics of Aerobraking and Aeromaneuvering Vehicles. An engineering tool for design estimates of aerobraking space vehicles will be provided. The approach is to: (1) perform systematic tests in vacuum chamber; correlate results with suitably developed analytical/semi-empirical model. (2) Impact sting-mounted into water at preset velocities, taking forcetime trace with suitable balance; models dominant first peak load, and (3) assess capability of finite element method to provide numerical solution of aerobraking problem.

**W77-70801** **910-39-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**AEROTHERMODYNAMICS**
Robert W. Abel 713-483-2863

The Engineering Design Integration (EDIN) Project is an activity sponsored by the Engineering Analysis Division (EAD) aimed at developing a Computer Aided Design (CAD) capability for JSC. The long-range goal of this activity is to achieve the capability to perform the design of the next major funded NASA project throughout the preliminary design process to the maximum practicable extent on the computer. The EAD is committed to investigating a CAD capability which will span the broadest meaning of CAD by developing and acquiring the software, hardware and support from other JSC organizations essential to this task. The result of this activity will be a clear understanding of the application of the computer aided design process to future engineering design requirements of JSC. The approach to developing the EDIN computer aided design system has been to make maximum usage of existing software and technology. The strategy has been to develop computer software which enables an engineering team to perform design integration on the computer and make maximum utility of existing analysis programs. The development efforts utilizing 910 funds are centered in three areas: (1) development of CAD capabilities and software (2) development technical analysis programs, and (3) development of design integration techniques and demonstration of their applicability through design simulations.

**W77-70802** **910-41-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**MAN SYSTEMS VEHICLE INTEGRATION**
L. M. Jenkins 713-483-4966

From concepts defined in initial FY-TP study, the objectives are to make detailed designs of selected servicing equipment or components, and fabrication and testing of the selected equipment in FY78 and FY79. The approach is to evaluate concepts for family of orbital construction/servicing equipment defined in concept study, perform tradeoffs to determine key construction/servicing equipment selection, make detailed design of selected equipment and accompanying test and simulation hardware, and fabricate development article and perform development tests and simulations at JSC in FY78 and FY79.

**W77-70803** **910-42-00**
Marshall Space Flight Center, Huntsville, Ala.
**SIMULATION**
Ray L. Lawrence 205-453-5935

The objectives are to: (1) develop simulation capability for Advanced Hybrid Computing System (AHCS) and Space Station orbital docking system analysis, (2) develop, high level programming language capability and remote access to AHCS, (3) determine system requirements for various Space Station stack and cluster concepts, (4) evaluate adaptability of existing docking mechanism designs for Space Station, and (5) compare manual and automatic docking system performance for Space Station.

**W77-70804** **910-46-01**
Lyndon B. Johnson Space Center, Houston, Tex.
**CONTAMINATION CONTROL IN OXYGEN SYSTEMS**
C. D. Howard 713-483-2941

The objective is to develop more realistic and cost effective cleanliness requirements for spaceflight systems. The approach is to determine, through a comprehensive research and testing activity, the ignition sensitivity of contamination commonly found in spacecraft and in oxygen storage and transportation systems.

**W77-70805** **910-47-00**
Marshall Space Flight Center, Huntsville, Ala.
**ENVIRONMENTAL CONDITIONS**
C. R. Chappell 205-872-3036

The objectives of this research are to investigate the naturally occurring environmental phenomena of spacecraft charging and the effects on charging caused by different surface materials, and to define an optimum system for the prediction of impending changes in the spacecraft environment due to eruptions of major solar flares. These objectives will impact the design and operation of a geosynchronous space station. The approach to be used for the first objective is to analyze the presently available ATS-6 data and to plan appropriate experiments for the study of charging phenomenon for the upcoming Air Force SCATHA satellite. For the latter objective a correlative analysis of available solar flare data will be undertaken to determine those observations which serve as flare precursors. Specific data to be used are Skylab/ATM flare observations, NOAA satellite data and data obtained with the MSFC vector magnetograph facility (RTSM). To accomplish these objectives the following tasks will be performed: (1) Spacecraft Charging at Geosynchronous Orbit, and (2) Solar Flare Alert System Definition.

**W77-70806** **910-49-00**
John F. Kennedy Space Center, Cocoa Beach, Fla.
**METEOROLOGICAL INFORMATION SYSTEMS**
P. Toft 305-823-2780

The objective of this effort is the improvement of meteorological forecasting and data gathering, transmission, and analyses at the Kennedy Space Center (KSC). The automation of meteorological data gathering, processing, historical storage, and access for operator usage will be investigated to enhance operating efficiency of the KSC Meteorological Prediction Center. Studies of lightning and related meteorological phenomena will be conducted to determine the most effective utilization of the unique measurements of lightning phenomena available at KSC.

**W77-70807** **910-50-00**
Marshall Space Flight Center, Huntsville, Ala.
**STRUCTURAL ANALYSIS**
John E. Key 205-453-3965

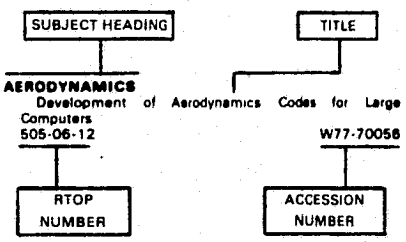
The objective of this RTOP is to provide new analytical tools to solve structural problems more efficiently and accurately for NASA programs such as space power systems, heavy-lift launch vehicles, single-state-to-orbit vehicles, space stations and large space antennae. The approach is to develop solid elements for the already efficient SPAR structural computer program. The solid elements will be incorporated on the MSFC computer and then tested and compared with known solutions. Isoparametric ring element and non-axisymmetric loading for the BOPACE elastic-plastic-creep program will be developed. These features will then be tested for validity on the MSFC computer. Multicycle proof tests will be performed on tough metal specimens and the results will be evaluated to determine the advantage, or disadvantages of multicycle proof testing. Individual tasks to be performed include: (1) solid Elements in SPAR, (2) modifications to BOPACE, and (3) multiple vs. single cycle proof testing.

# SUBJECT INDEX

FISCAL YEAR 1977

## RTOP Summary

### Typical Subject Index Listing




A title is used to provide a more exact description of the subject matter. The RTOP accession number is used to locate the bibliographic citations and technical summaries in the Summary Section.

## A

## B

# C

# D

## E

## F

## G

## H

## J



## K



## L

## M

## N

## O

## P

## Q



## R

## S

## T

## U

## V

## W

## X



## Y



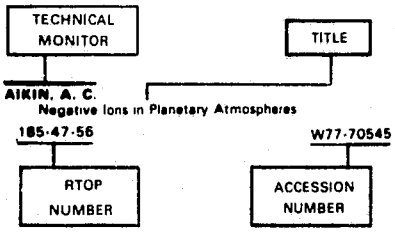
## Z

# TECHNICAL MONITOR INDEX

FISCAL YEAR 1977

## RTOP Summary

### Typical Monitor Index Listing




A title is used to provide a more exact description of the subject matter. The RTOP accession number is used to locate the bibliographic citations and technical summaries in the Summary Section.

## A



## B

## C

## D



## E



## F



## G



## H

## J



## K

## L



## M



## N

## O



## P



## Q



## R

## S



## T



## U



## V

## W



## Y



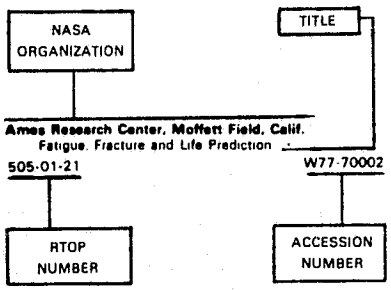
## Z

# RESPONSIBLE NASA ORGANIZATION INDEX

## RTOP Summary

FISCAL YEAR 1977

### Typical Responsible NASA Organization Index Listing




Listings in this index are arranged alphabetically by Responsible NASA Organization. The title of the RTOP provides the user with a brief description of the subject matter. The accession number denotes the number by which the citation and the technical summary can be located within the Summary Section. The titles are arranged under each Responsible NASA Organization in ascending accession number order.

## A

**Ames Research Center, Moffett Field, Calif.**

Fatigue, Fracture and Life Prediction
505-01-21 W77-70002

Fire Resistant, Non-Toxic Polymers
505-01-31 W77-70004

Fire-Retardant and Laser Countermeasure Materials for Military Programs
505-01-32 W77-70005

Unsteady Aerodynamic Loads and Aeroelasticity
505-02-21 W77-70013

Noise Reduction Technology
505-03-12 W77-70028

V/STOL Aircraft and Propulsion System Integration
505-04-11 W77-70037

Development of Aerodynamics Codes for Large Computers
505-06-12 W77-70056

Physical Modeling and Verification of Advanced Computer Codes
505-06-13 W77-70057

Turbulent Boundary Layers
505-06-15 W77-70060

Effects of Aircraft Flow Fields on a Laser Beam
505-06-17 W77-70061

Definition of Optimized Processor for Computational Fluid Dynamics
505-06-18 W77-70062

Prediction Methods for the Aerodynamics of Cruise Flight
505-06-19 W77-70063

Unsteady Aerodynamics
505-06-21 W77-70064

Airframe Aerodynamic Noise of Short-Haul Aircraft
505-06-23 W77-70065

Aerodynamics of Multi-Element Airfoils and Wings
505-06-34 W77-70070

Advanced Wind Tunnel Concepts
505-06-42 W77-70072

Flow Measurement Techniques
505-06-43 W77-70074

High Angle of Attack Aerodynamics
505-06-97 W77-70079

Application of Guidance and Navigation Theory to Operations of Future Short Haul Aircraft
505-07-10 W77-70080

Application of Advanced Control Theory to the Automatic and Manual Control of Future STOL, VTOL, and Rotorcraft
505-07-11 W77-70081

Aviation Safety Research and Technology - Fire Technology
505-08-21 W77-70093

Hazard Avoidance - Wake Vortices and Wind Shear
505-08-22 W77-70098

Hazard Avoidance - Data Processing and Flight Simulation from Aircraft Accident Recordings
505-08-23 W77-70101

Aircraft Systems Operational Safety and Efficiency Improvement
505-08-31 W77-70106

Acceptance of Aircraft Operations - Technology Assessment
505-09-12 W77-70109

Ride Qualities Criteria Validation/Pilot Performance During Low Altitude High Speed Flight
505-09-22 W77-70112

Aircrew Performance and Aviation Safety
505-09-32 W77-70114

Flight Management Systems - Aircrew Supervisory Control Functions
505-09-33 W77-70115

Simulation Technology for Aeronautics
505-09-42 W77-70118

Aerodynamic Performance Technology for Third-Level Carrier Aircraft
505-10-12 W77-70120

Helicopter Aerodynamic Performance, Dynamics and Noise
505-10-21 W77-70123

Tilt Rotor Aircraft Aerodynamic Performance, Dynamics, and Noise
505-10-22 W77-70125

Rotorcraft Flight Dynamics
505-10-23 W77-70126

Advanced Tilt Rotor Aerodynamics
505-10-27 W77-70130

VTOL Aerodynamic Performance
505-10-31 W77-70131

VTOL Flight Dynamics
505-10-32 W77-70132

NASA/Navy Multimission V/STOL Aircraft Technology Development
505-10-35 W77-70133

VTOL Military Aircraft Cruise and Maneuver Aerodynamics
505-10-36 W77-70134

STOL/RTOL Low-Speed Aerodynamics
505-10-41 W77-70135

STOL/RTOL Flight Dynamics
505-10-42 W77-70136

R/STOL Cruise Aerodynamics
505-10-43 W77-70137

High Subsonic/Transonic Aircraft Aerodynamic Performance
505-11-12 W77-70140

Oblique Wing Flight Test Technology
505-11-13 W77-70141

Civil Aircraft Development Testing (Fee Basis)
505-11-14 W77-70142

Civil Aircraft Development Testing (Other Government Organizations Except DOD)
505-11-18 W77-70146

Military Aircraft - Aircraft Aerodynamics
505-11-21 W77-70148

High Maneuver Missile
505-11-22 W77-70149

DOD Assistance
505-11-41 W77-70161

Development of Computational Techniques
505-15-31 W77-70163

Civil Air Transportation System and Concept Studies
791-40-13 W77-70167

Military Aircraft Concept Analysis and Methodology Development
791-40-21 W77-70169

Aircraft Concept Analysis and Methods Development
791-40-27 W77-70170

Analysis of Factors Influencing the Growth of Civil Aviation and Development of A Methodology for Assessing the Benefits of Aeronautical R&T
791-40-41 W77-70172

Integrated Multi-modal Transportation System Technology
791-40-42 W77-70173

Fire-Resistant Materials Engineering
510-56-01 W77-70179

General Aviation Advanced Avionics System
512-52-01 W77-70189

Analysis of the Operational Compatibility of Future Civil Air Transportation Concepts
513-50-53 W77-70193

Feasibility and Validation of Low Cost Microwave Landing System Avionics
513-50-54 W77-70194

Simulation Methods for the Certification and Failure Effects Analysis of Digital Avionics and Flight Control Systems
513-50-55 W77-70195

Microwave Landing System Validation for STOL Aircraft Applications
513-53-02 W77-70197

STOL Operating Systems Experiments Using Models and the Civil/Military Microwave Landing System (MLS)
513-53-03 W77-70198

Investigation of the Use of Strapdown Inertial Sensor Units for the Integration of Flight Control, Guidance and Navigation Functions
513-53-05 W77-70199

Terminal Area Effectiveness Program - Optimization of Flight Procedures of Short-Haul Transport Aircraft
513-53-06 W77-70200

VTOL Operating Systems Experiments
513-54-01 W77-70201

Advanced V/STOL Aircraft Design and Application Studies
514-50-01 W77-70203

Lift-Cruise Fan System Technology Program-Design Studies
514-50-02 W77-70204

Wake Vortex Minimization Flight Research
514-52-01 W77-70207

Numerical Simulation of Vortex Wakes
514-52-02 W77-70208

Human Factors in Aviation Safety
515-51-11 W77-70213

Oblique Wing Aircraft System Studies
516-50-10 W77-70214

Short-Medium Range Advanced Technology Aircraft Design Studies
516-50-11 W77-70215

YF-12 Disciplinary Research
516-51-02 W77-70219

F-111 TACT Research Aircraft
517-51-02 W77-70225

Fuel Tank Sealants
743-01-02 W77-70235

SCAR - Stratospheric Emission Impact
743-02-22 W77-70241

Tilt Rotor Research Aircraft Program
744-01-01 W77-70253

AMST Program Participation
769-01-01 W77-70255

Quiet Short-Haul Research Aircraft (QSRA) R/STOL
769-02-02 W77-70260

Surface Physics
506-16-11 W77-70264

Physics and Chemistry of Solids
506-16-12 W77-70266

Control of Environmental Effects
506-16-31 W77-70274

Planetary Entry Technology
506-16-41 W77-70278

Thermal Protection Materials for Space Transportation
506-16-42 W77-70279

Space Vehicle Dynamics
506-17-31 W77-70293

Video Inertial Pointing System for Shuttle Astronomy Payloads
506-19-15 W77-70312

Cryogenic Technology for Cooling Detectors Below 10 Kelvin
506-25-22 W77-70370

Quantum Electronics
506-25-32 W77-70377

Physics and Chemistry of Gases
506-25-34 W77-70378

Structure and Properties of Surface Layers
506-25-35 W77-70379

Laser Energy Conversion
506-25-41 W77-70382

Development of Instrumentation for the Measurement of Flow-Field Parameters
506-26-12 W77-70385

Gas Dynamics Research
506-26-21 W77-70387

Computational and Experimental Aerothermodynamics
506-26-22 W77-70388

Planetary Probe Aerothermodynamic Technology
506-26-24 W77-70390

Space Shuttle Configurations and Aerothermodynamics
506-26-31 W77-70392

Systems Analysis of Post LANDSAT-D/SEOS System
790-40-45 W77-70398

Definition of Space Flight Technology Experiments
750-01-20 W77-70404

Solid Earth Dynamics/Earthquake Prediction/Magnetic Field Determination
161-02-04 W77-70420

Severe Storms and Local Weather Research
175-10-10 W77-70437

Climate Research, With Emphasis on Stratospheric Perturbations
175-40-10 W77-70447

Stratospheric Measurements and Analysis Program
176-10-11 W77-70455

## G

## H



## J

## L

**Lewis Research Center, Cleveland, Ohio.**



**Lyndon B. Johnson Space Center, Houston, Tex.**

## M



## N

## S



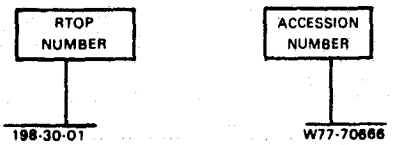
## W

# RTOP NUMBER INDEX

FISCAL YEAR 1977

## RTOP Summary

### Typical RTOP Number Index Listing




This section may be used to identify the RTOP accession number of reports covered in this journal. Thus this section of this index may be used to locate the bibliographic citations and technical summaries in the Summary Section. The RTOP numbers are listed in ascending number order.





PAGE INTENTIONALLY BLANK

164